ENVIRONMENTAL QUARTERLY

April • 1960

The Pioneer Space Age Publication of Environmental Simulation, Testing, Engineering and Equipment Manufacturing

INDEPENDENTLY PUBLISHED

Volume 6 • Number 2

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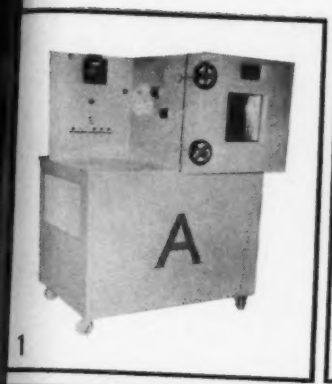

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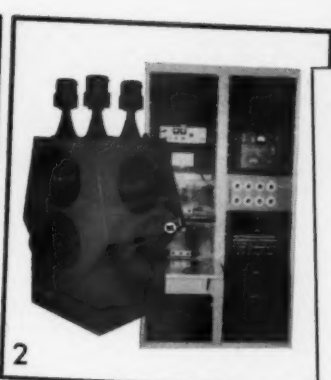
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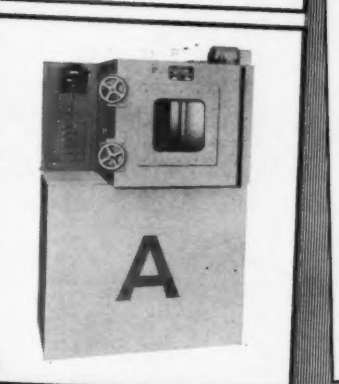

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79	400	1	36	16	9
81	1300	1¼	111	46	23
83	1700	1¼	151	66	37
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ENVIRONMENTAL QUARTERLY

The Pioneer Space Age Publication of Environmental Simulation, Testing, Engineering and Equipment Manufacturing

April • 1960 Volume 6 • Number 2

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Quarterly welcomes competent expressions of opinion, but statements in its pages do not necessarily reflect its views. Right is reserved to extract portions of letters and other material submitted for publication. Correspondents must be fully identified, but names will not be published if such a request is made.

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If you are testing to MIL-E5272C get complete information on these three great new centrifuges.

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Model No.	Diameter	Test Object Weight	Capacity G-Pounds	RPM Max.	G-Range Max.	Test Object Dimensions
A-1010	30" table	50 lbs. dead weight	2,500	800	.1 to 200 g's	
A-1020	60" arm	100 lbs. dead weight	10,000	600	.1 to 250 g's	12" cube
A-1030	96" arm	100 lbs. dead weight	10,000	355	.1 to 150 g's	18" cube

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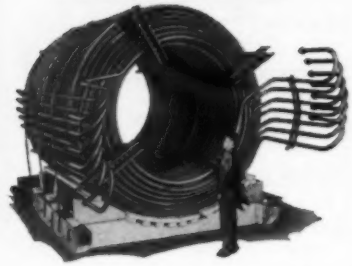

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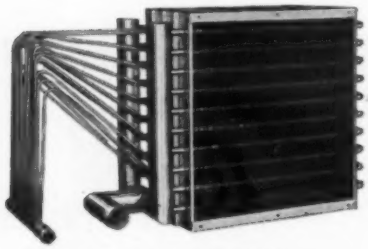

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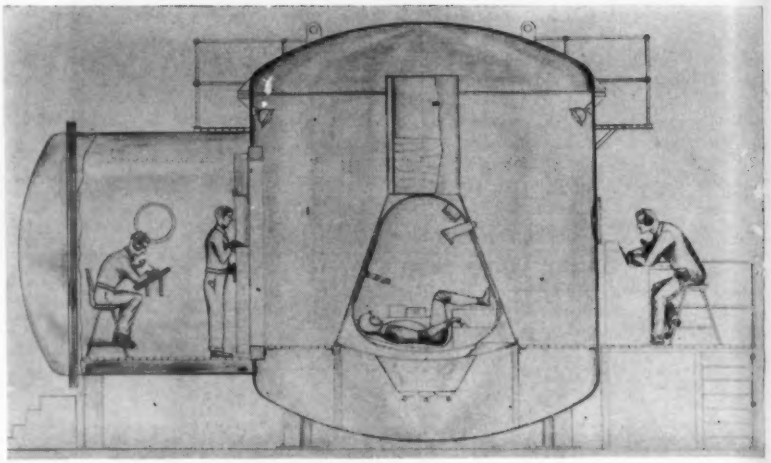

PROOF POSITIVE of environmental testing's role in space is this 12-foot wide, 15-foot high altitude simulator being built by Tenney Engineering, Inc., Union, N. J., for Cape Canaveral to accommodate the Project Mercury capsule. It will achieve 225,000 feet with controlled dive rates of up to 50,000 feet per miuute and emergency descent in six seconds, according to Robert H. Brown, vice president of Tenney. From his "sitting" position flat on his back, the astronaut will contact the outside via a man-made umbilical cord, and his reactions in the simulated void will be watched through windows and ports.

Environmental testing will occupy a dominant position in the government's 10-year plan to launch 260 satellites, concluding with an American man (or woman?) on the moon.

The launchings and space probes, NASA told Congress, will start with 12 this year and range from 23 to 30 a year in the following nine years.

The timetable calls for landing payloads on the moon, surveying Mars and Venus and establishing a laboratory in space, as well as that great dream of science, manned flight to the moon "beyond 1970."

A Great Year A-Comin'

Super-thrust rockets, such as the 1½ million-pound-thrust Saturn, are counted on to deliver the more ambitious latter part of the plan. The first payload on the moon and the first astronaut orbiting the earth, however, are slated for just next year, three years before the first Saturn launch.

Dr. Wernher von Braun, rocket pioneer, is not greatly impressed with the U. S. schedule. He feels the Soviets may orbit the first man around the earth and put a payload on the moon this year . . . The accuracy of the Soviet's two big missile shots into the Pacific in January point to a high degree of environmental testing, but details on their chambers and shakers are lacking. EQ's attempt last year to find out was politely rebuffed. We'll try again.

Titan Bulwarks Ike

Despite the gloom of some, President Eisenhower stoutly defended America's "admirable" record in space exploration . . . As if to echo his words the Air Force got off a Titan at Cape Canaveral which for the first time separated and fired its second stage. It was the first successful firing in nine months of what is potentially America's biggest war rocket.

Scientists at an international meeting in Nice, France, reported an unexplained rise in temperature in the upper layers of the earth's atmosphere at certain times of the year, and that the magnetic center of the earth is off the true center by about 300 miles toward the Pacific . . . And out in the Pacific, the Navy dropped two men more than seven miles to the bottom of the great Marianas Trench in a thick-hulled bathyscaph. Even the Russians don't claim to have gone deeper.

All in a day's environment!

Very Readable . . .

. . . "Simulating Space," layman's type, non-technical review of the state of the environmental art by Alexander I. Newman, president of Hudson Bay Co., Chicago chamber maker, and Robert J. Dennis, chief liaison engineer, Inland Testing Laboratories division of Cook Electric Co., in the Dec. '59 issue of *Industrial Research*.

. . . Letters like that from Charles F. Conrad, printed in an adjoining column, and items like the following from our readers: From LAP, Los Angeles—"Once again we wish to compliment you . . . EQ is well received here in the West and quoted widely." And WS, acquisitions chief of a Midwest scientific library writes: "This journal is the outstanding

one in its field. EQ is much appreciated by our library and much used by our patrons."

Think, Men, Think.

In any environment, success fosters complacency. The hot pursuit of answers to day-by-day problems leaves little time, indeed, for contemplating larger goals. As technical victory is piled onto technical victory, the feeling inevitably grows that "all's right with the world," when we really may be doing nothing more than besting a treadmill.

EQ's "Path of the Environment" series is an effort to bring the larger picture into focus. One way is to sketch the outlines of tomorrow's needs and probabilities in the words of men eminently qualified to know. Recommended reading in this category is "Vibration Testing—Yesterday, Today and Tomorrow," by Cameron G. Pierce, this issue's "Path" entry.

Of Miscellaneous Interest . . .

Only one unsigned RSC to report this month. Someone at the Brooklyn Naval Base wants more information on January issue numbers 9, 13, 39 and 42. Be glad to oblige if the reader will identify himself.

Ideas, anyone? Last year, EQ inaugurated an "Idea Swap Shop," as a kind of forum or exchange place for anyone with a problem others might be able to help on. The response has been disappointing. Not too good an idea?

Letters to the Editor

For Mechanical Refrigeration

EDITOR,
ENVIRONMENTAL QUARTERLY:

There has been quite a lot of publicity recently on CO_2 cooling of testing chambers. G. W. Carr, of Electronic Communications, Inc., referred (EQ, Jan. '60) to conversion of a test chamber. The 7½ hours he mentioned for cooling from ambient to —65° C. would be unusually long indeed, for modern cascade mechanical refrigeration. He must have had an inefficient or obsolete system. Typical cooling times for mechanical refrigeration can be 20 to 30 minutes with reasonable size equipment. Forty-five minutes is quite standard.

It is true that the cost of electricity for a CO_2 system is less than to operate a mechanical system. A customer should not, however, overlook the fact that CO_2 gas *per BTU of refrigeration effect costs approximately 14 times more than* electricity for a mechanical system.

CO_2 is "gone with the wind" once used for cooling. The use factor is the real deciding point. A heavy CO_2 usage factor could offset mechanical equipment first costs in a matter of months. After that the difference for lower operational costs for the mechanical system is pure saving.

Water cost can be held to a minimum by use of a water cooling tower and recirculation. Usage will then be reduced 90 per cent. Air cooled systems are also available.

A combination of mechanical refrigeration to —100 degrees F., supplemented by liquid nitrogen for colder temperatures is very practical, and economical.

Some of the reasons and justifications for CO_2 cooling parallel those put forth by the icebox manufacturers when they were attempting to find reasons for continuing the use of iceboxes versus electric refrigeration.

Conrad, Inc., manufactures chambers for use with CO_2 cooling systems as well as for cascade refrigeration Freon 13 and Freon 22 systems. Each type has its place in the industry, and selection should be on the basis of first cost, usage factor, and accuracy of control required.

CHARLES F. CONRAD
Conrad, Inc.
Holland, Mich.
Feb. 16, 1960

(Environmental Quarterly welcomes comments from its readers and hopes others will follow Reader Conrad's example. By the same token, published letters themselves are subject to comment, praise or rebuttal by readers. Correspondents are urged to keep their letters short, and are reminded that what they write is subject to being abstracted for publication. Letters must be signed, but signatures will be withheld upon request.—The Editor)

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AROUND THE ENVIRONS...

The Environment Meets in the West

Environmental scientists and engineers by the hundreds and possibly thousands will head for Los Angeles in early April for the fourth annual meeting of the Institute of Environmental Sciences.

It is the first national meeting of the environmental fraternity since the merger, at the Chicago convention last year, of the Institute of Environmental Engineers and the Society of Environmental Engineers, forming the IES. It is also the first nationwide environmental meeting to be held in the West. Formerly the annual meetings were under the auspices of the IEE.

Four events will hold attention at Los Angeles' Biltmore Hotel April 6-9.

Hyper Environments

A three-day program, April 6-8, of technical sessions on the general subject of "Hyper Environments . . . Space Frontier."

A concurrent four-day trade show with 50 or more exhibitors scheduled to participate.

The annual meeting of the IES at which, if custom is followed, Executive Vice President William L. Vandal will succeed to the presidency. The retiring president is Harold C. Jones, of the University of Maryland.

The annual meeting of the Environmental Equipment Institute, a trade association of equipment manufacturers. Charles C. E. Harris, of Harris Refrigeration Co., is the retiring president, and precedent would have had him succeeded by Nick E. Miller, of Murphy & Miller, Inc., who had been executive vice president. Miller, however, has shifted to other duties with his firm and is no longer Murphy & Miller's representative to the EEI.

More than 65 papers are expected to form part of the proceedings of the meeting. General topics are "The Environments (What We Know About Them)," "Terrestial Support," "Design for Environment" and "Proof Testing and Reliability."

To Cover Many Aspects

Subject matter will range from "Thirty Thousand Ways to Help Environmental Engineers," by R. J. Mann, of the National Academy of Sciences, to "Performing Man-Sized Tasks in Space," by S. N. Roscoe, of Hughes Aircraft Company. Both material and physiological aspects of hyper environments will be discussed fully.

Convention-wide luncheons will be held on Wednesday, April 6, and Thursday, April 7.

Beat The Heat, Says Sam

Travelin' Sam, the monkey that rode like a man into space and back, basked in 90-degree summertime warmth despite searing 2,000 degrees-plus on the skin of his Little Joe capsule. All due to a new compound—Thermo-lag—sprayed on the outside like paint, says the Emerson Electric Manufacturing Co., which developed it. The stuff dissipates heat by sublimation, similar to the way dry ice vaporizes from solid to gas.

IES Sponsors Standards Move

A long-sought project to establish nationwide standards for environmental terminology got under way in February under the auspices of the Institute of Environmental Sciences and the American Standards Association. An ASA conference attended by 20 representatives of 16 organizations fixed the scope of the project as selecting and defining terms to describe factors of environment.

The IES, which had requested the February conference, agreed to act as sponsor of the project. Under ASA procedure, it can go ahead as soon as the ASA's Miscellaneous Standards Board approves the conference's recommendations. The first step will be to form a committee from 20 organizations, nine government agencies and several ASA groups that had been invited to attend.

To Use Navy Standard

After considerable discussion as to whether to cover physiological as well as equipment aspects, the conferees decided on the broad approach. A proposed military standard on environmental terminology prepared by T. W. Johnson, of the Naval Weapons Plant, will be used as a starting point.

The point was made that this is a good time to establish an American standard because a number of groups are currently writing definitions in the environmental field.

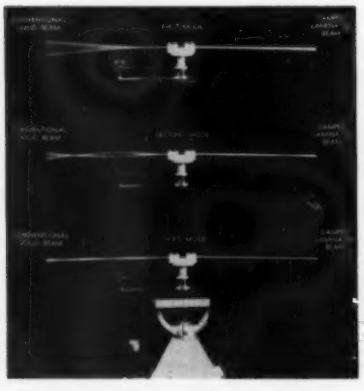
Invited organizations, in addition to IES, are: Acoustical Society of America,

(*Continued on Page 10*)

'Jelly Sandwich' Structure Cuts Vibration Drastically

A group of engineers gathered around a shake table to which two strips of aluminum had been attached. The table was turned on, and as the hum of vibration rose, the tip of one strip flipped back and forth in a blur of several inches. The other strip barely moved.

The strips seemed identical in size and shape. They were bolted alike to the table. They received identical treatment. What was the secret?



Engineers of Barry Controls, Inc., Watertown, Mass., pointed to the cross-section of the almost motionless strip. It was really two strips, laminated together with a special viscoelastic material like a jelly sandwich.

Resisting A Slide

When, under stress, the sandwich sought to bend, the top layer tried to slide in relationship to the bottom one. But the "jelly" resisted the sliding action, successfully absorbing the alternating strains of the vibration waves.

The dramatic reductions in vibration at left—showing conventional solid vs. damped laminated beam at 17, 105 and 300 cps (top to bottom)—are achieved with Barry Controls, Inc.'s unique, steel-celled, viscoelastic-damped RIGIDAMP structural members (below).

The unique means of inhibiting vibration was developed by Barry engineers Jerome E. Ruzicka and Richard D. Cavanaugh. It can be applied, they said, to metal or plastic sheets, I-beams, channels, or any structural members and production assemblies.

Barry believes its RIGIDAMP, the trademarked name for the construction, will be used for such things as electronic circuit boards and chassis, shelves, dust covers, aircraft parts, test fixtures, missile skins and relays.

Answer To 'Many Vexing Problems'

"We expect," said Ervin Pietz, Barry president, at a dramatic demonstration in New York, "that RIGIDAMP structures will solve many of the vexing problems of extreme vibration created by all types of modern high-energy power plants."

At resonant frequencies conventional structures amplify impressed vibrations some 60 to 300 times. By contrast, Barry calculates that its RIGIDAMP structures range from 5 to 10 times excitation vibration.

Construction can be either laminated or cellular.

(*Continued on Page 11*)

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environmental testing

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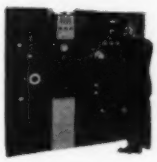
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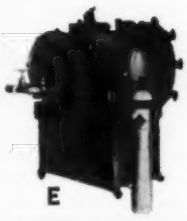
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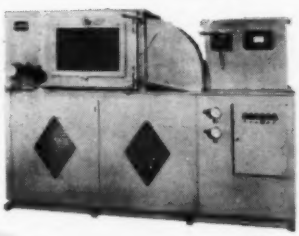
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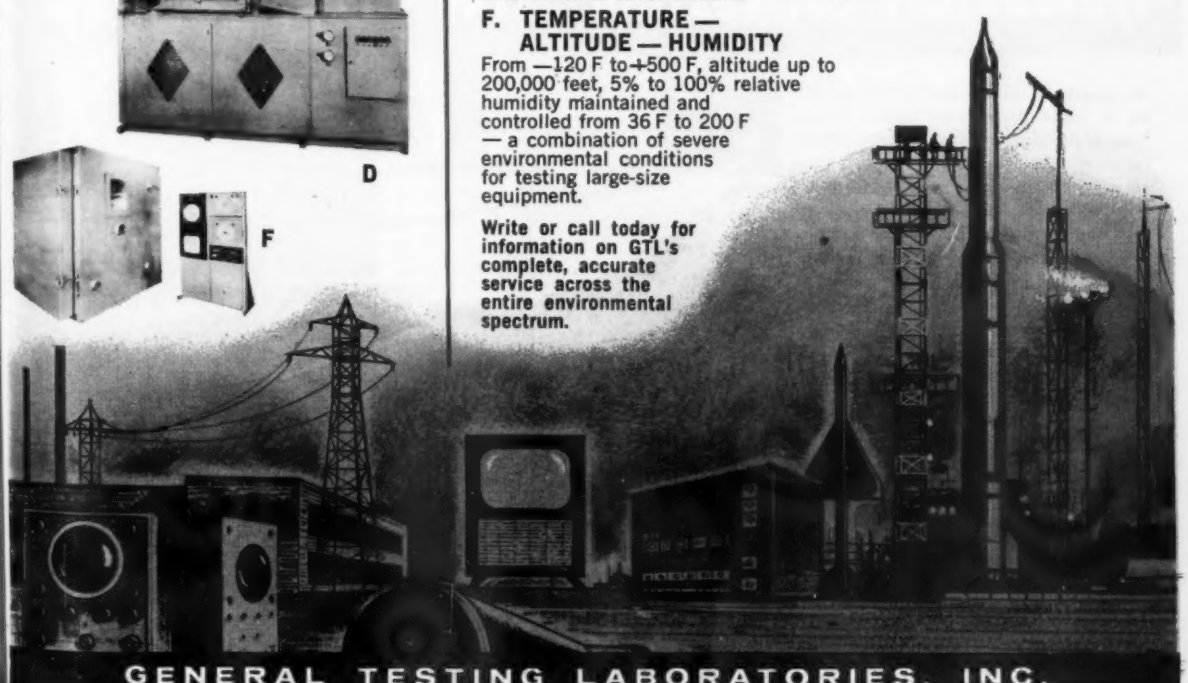


GENERAL TESTING LABORATORIES, INC.

58 WASHINGTON AVENUE CARLSTADT, NEW JERSEY

Tenney Hyper-Environment Chamber To Be Exhibited

Tenney Engineering, Inc., Union, N. J., will be showing one of its latest hyper-environmental test chambers at the April IES show in Los Angeles. Designed for rocket and satellite component tests, the chamber, according to Robert H. Brown, Tenney vice president, will produce 1200° F. of radiant heat at 500,000 feet altitude (1 x 10^{-6} mm. Hg. absolute). This is one of the hottest and highest ever combined simultaneously, he said.

Unusual features include a vapor trap operation in the range of —120° F. and an automatic hot gas defrost. The chamber measures 4' x 8' x 7' high and has a cylindrical work space 30" in diameter and 30" deep. (*Circle EQ RSC G.*)

For the show, the control console will incorporate an electronic schematic which lights up as the various parts of the chamber function.

NBS Cryogenic Lab Develops Liquid Hydrogen Refrigerator

An automatic, closed circuit liquid hydrogen refrigerator system has been developed by the Cryogenic Engineering Laboratory of the National Bureau of Standards for physical research. It is claimed to be "far safer and more efficient" than a remotely located liquifier.

Hydrogen vapor from an evaporator is used to refrigerate a liquid hydrogen bubble chamber down to about —214° F. The closed circuit uses one-third as much power (300 watts) as the process of evaporating liquid from a vented reservoir, and the handling of many small dewars of liquified hydrogen is eliminated.

The system is described in detail in a 39-page report, *Design and Construction of a Liquid Hydrogen Temperature System*, PB 151397 by D. B. Chelton and others, released by the Department of Commerce, Office of Technical Services, Washington 25, D. C. The report costs 75 cents.

New Numbers Abbreviations

In keeping with recommendations of the International Committee on Weights and Measures, the National Bureau of Standards has adopted new prefixes for multiples and submultiples of units, including four new ones, indicated by asterisks. To illustrate, the 10^{-12} prefix being pico, 10^{-12} farad is 1 picofarad, or simply 1 pf.

Multiples and sub-multiples	*Prefixes*	*Symbols*
1 000 000 000 000 = 10^{12}	tera*	T
1 000 000 000 = 10^{9}	giga*	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto	h
10 = 10	deka	dk
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	u
0.000 000 001 = 10^{-9}	nano*	n
0.000 000 000 001 = 10^{-12}	pico*	p

Environmental Standards Project Gets Underway

(*Continued from Page 8*)

Aerospace Industries Association of America, American Bureau of Shipping, American Council of Independent Laboratories, American Institute of Electrical Engineers, American Rocket Society, American Society for Quality Control, American Society for Testing Materials, American Society of Mechanical Engineers, Atomic Industrial Forum, Automobile Manufacturers Association.

Also, Electronic Industries Association, Environmental Equipment Institute, Institute of Radio Engineers, Instrument Society of America, National Electrical Manufacturers Association, National Safe Transit Committee, Society of Automotive Engineers, Society for Experimental Stress Analysis.

Government agencies are: National Aeronautics and Space Administration, National Bureau of Standards, Department of Defense, Air Research and Development Command, Army Ordnance, Signal and Transportation Corps and the Navy Bureaus of Weapons and Ships.

ASA bodies are the Telephone Group and sectional committees on electrical terms, electronic components and mechanical shock and vibration.

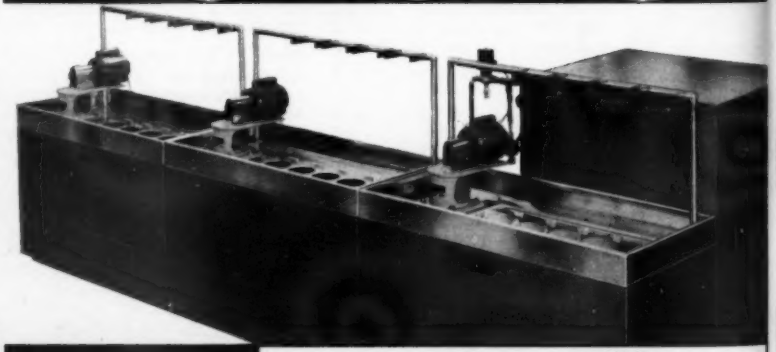
28th Shock, Vibration Symposium

The 28th Shock, Vibration and Associated Environments Symposium was held in Washington Feb. 9-11.

PRECISION 3-ZONE MASS PRODUCTION LIQUID TEMPERATURE CALIBRATION BATHS +150°C. to —85°C.

For precision temperature calibration on a mass production basis. Three separate agitated liquid baths. Fast recovery after loading. Complete recovery in 10 minutes with 1,000 BTU thermal load. Stainless steel cabinet tops contoured at rear to drain off oil drippings from fixtures hung on drying racks. Open rolled edges on top wall prevent liquids from creeping beyond top. Temperature variation in each bath less than 1°C. ± .1°C. point control (repeatability, speed of response, and on-off differential). Each chamber, 5 cu. ft.

TEMP. RANGE	HOT +150° to +50°C.	MEDIUM +50° to +20°C.	COLD −20° to −85°C.
CAPACITY	6,000 BTU/hr.	1,000 BTU/hr.	6,000 BTU/hr.



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Barry 'Rigidamp' Beams Reduce Vibration Sharply

(Continued from Page 8)

While expected to perform most significantly in new systems, damped members can be applied to existing equipment to "fix" resonant responses which are causing difficulties, Mr. Pietz said.

Fatigue Fighter, Too

The new Barry structures are also expected to greatly extend the fatigue life of materials by reducing ambient stress levels.

The viscoelastic material was said to perform best at room temperatures. Its resonance amplification factor climbs sharply below 0° F., and at about 200° F. it is twice as great as at room temperature, although still far below that of a solid beam.

A viscoelastic damped member or structure has slightly less load carrying capacity than a conventional member of the same material and cross section. For identical stiffness, structural damping imposes a light increase in weight. For identical cross section it means reduced load capacity. Because many designs are based on dynamic stress level, however, RIGIDAMP designs may not require an increase in weight or cross section.

Because special techniques must be used and because application knowledge is critical to success, Barry announced that it does not plan to market damped structural members as materials, but will provide design and fabrication services to solve specific dynamic problems.

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HYGE 6000	Large laboratory model. Thrust capacity to 40,000 lbs.; acceleration, 2000G.
HYGE 3000	Small laboratory model. Thrust capacity to 10,000 lbs.; acceleration, 500G.
NEW PRODUCTION LINE HYGE	Thrust to 15,000 lbs.; acceleration, 100G. Provides most widely specified shock pulses: MIL-E-5272A (11 ±1 ms half-sine) and Ramo-Woolridge (6 ±0.5 ms Sawtooth). 5 tests in 5 minutes at less than 5¢ per test.

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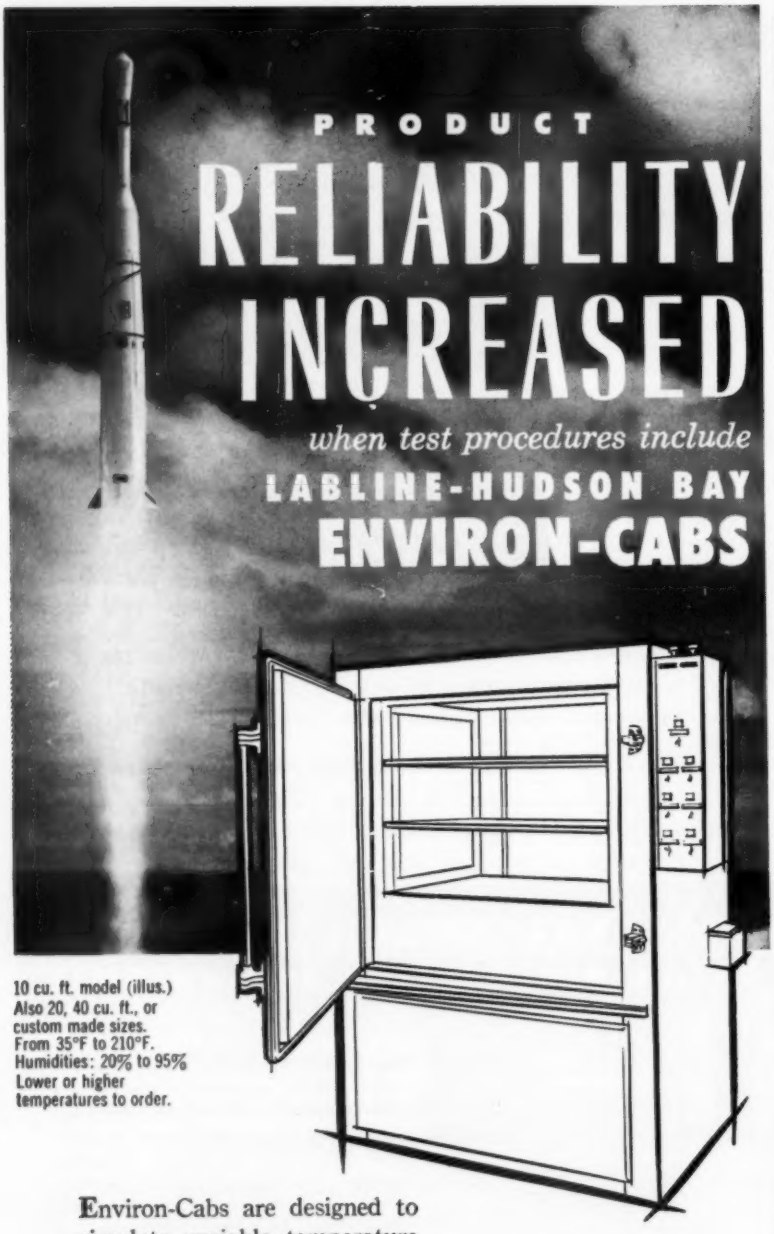

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Around The Environs

Membership Spin-Off Studied By IES Mid-Atlantic Chapter

Because of the difficulty of getting members together simultaneously from the Philadelphia, Baltimore and Washington areas, the IES' Mid-Atlantic chapter is studying the feasibility of splitting up.

At a chapter meeting at the House of Welsh, Baltimore, in February, a committee was appointed to study a plan to create separate Philadelphia and Baltimore chapters out of the Mid-Atlantic group.

Speakers at the meeting were Dr. John K. Hilliard and Dr. Walter T. Fiala, who only recently were named director and chief physicist, respectively, of the newly formed Research division of Ling-Altec Electronics, Inc. Of particular interest was their discussion of an electro-pneumatic transducer said to produce 174 db in conjunction with low frequency and high frequency driver units.

Southern Tier Chapter Told Of Automatic Data System

An automatic system for measuring and recording voltages and currents in environmental testing of digital computer circuits was described recently at the Southern Tier chapter of the Institute of Environmental Sciences at Vestal, N. Y. Harold J. Beal, IBM engineer, said the automatic system reduces to a minimum tedious manual measurements and produces highly accurate data fast.

Used in life testing of transistors and computer circuits, the system consists of two consoles which impress test conditions and record the resulting voltages, a data converter which digitizes the analog voltage and passes it on to the data recorder and an IBM punch card machine. Any chosen parameter can be examined from the punch cards and the exact cause of any malfunction pinpointed, Beal said.

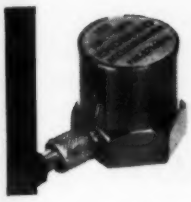
The chapter, of which W. G. Murray, project engineer, IBM, Owego, N. Y., is president, is conducting a membership drive. Dick Moran, of Components for Industry, Tonawanda, is membership chairman.

The next chapter meeting is a dinner, scheduled for May 26.

Govt. "Yellow Pages" Directory

The Defense Department has compiled a 20-page directory of military agencies responsible for development of missile ground support equipment. Divided into Army, Navy and Air Force sections, it lists components, the agency, and the man to see.

On sale by the U. S. Dept. of Commerce, Office of Technical Services, at 50 cents, the directory is called *Technical Resources Directory—Missile Ground Support Equipment*, PB 161103.



FORD VIBRATION INSTRUMENTATION: The Ford Motor Company entered the experimental gas turbine engine field in 1952. The Ford Turbo Machines Department is now engaged in research and development of a turbine engine and a working model has been tested in a tilt-cab truck. An obsolete engine, the Ford 702, has developed 160 horsepower at shaft speeds up to 36,000 rpm. ■ A new supercharged 300 horsepower turbine engine was recently announced by Ford Engineers. Known as the "704," the engine weighs 650 pounds installed, compared to 2,700 pounds for a truck diesel engine of comparable horse-

ENDEVCO TRANSDUCERS SOLVE VIBRATION ANALYSIS PROBLEM

power. The engine has two stages of compression, each operating at a 4:1 pressure ratio. Two burners are used for driving the dual compressors, the low speed wheel turning at 46,500 rpm and the high speed wheel at 91,500 rpm.

THE PROBLEM: The Ford Test program requires a wide variety of instruments to measure, control and record performance data of component parts. Measurement of vibration, for example, is a critical factor in this program. Vibrations that may cause metal fatigue, oil film breakdown, overheating, etc., are discovered during tests on individual engine "stands."

THE SOLUTION: Ford engineers use a total of six Endevco Series 2200 Accelerometers providing frequency responses up to 6,500 cycles per second. The accelerometers are connected to bearing test rigs, for example (see photo). The accelerometers relay measurements of acceleration movements in turbine shafts from three coordinates (radial vertical, radial horizontal and axial). Temperatures of the metal housings to which the standard Endevco transducers are attached average up to +150°F. Temperatures at which the water-cooled, heat-resistant models are used range up to +1000°F or more. The large self-generated output of the Endevco accelerometers eliminates the need for additional stabilization of a power supply.

THE RESULTS: The Endevco transducers are attached with a single-pole threaded bolt. The signal is fed through an Endevco amplifier to an oscilloscope or panoramic analyzer. The analyzer concentrates on a small section of the total signal and may present from 4 to 10 harmonic vibrations of different frequencies being fed from the unit at one time. This analyzer separates the frequency bands into individual bands, which it then sweeps from 20 to 40,000 cycles every second, measuring the frequency and amplitude in millivolts. ■ Ford Technicians convert these vibration records by mathematically integrating acceleration with respect to time to obtain the displacement or housing vibration. Thus, they locate the sources of objectionable resonance and take steps to eliminate or reduce vibration in the overall design. ■ Endevco accelerometers have also served as pickups for determining spring rate and damping characteristics of rubber bonded bearings. • **ENDEVCO CORPORATION** • 161 EAST CALIFORNIA BOULEVARD PASADENA, CALIFORNIA • PHONE SYCAMORE 5-0271

Close-up shows two Endevco Accelerometers on bearing test rig in Ford Instrumentation Section, Dearborn, Michigan. Cable passes to Endevco Amplifier (not shown on right).

(First of Two Articles)

Shock Testing Instrumentation

by Maxwell Lazarus
Project Manager
Barry Controls Incorporated

THE BASIC SHOCK MEASUREMENT system usually consists of an accelerometer, several component "black-boxes" and a recording instrument. The "black-boxes" could be filters, amplifiers and so forth; however, the transducer, or in this case the accelerometer, is the heart of any such system.

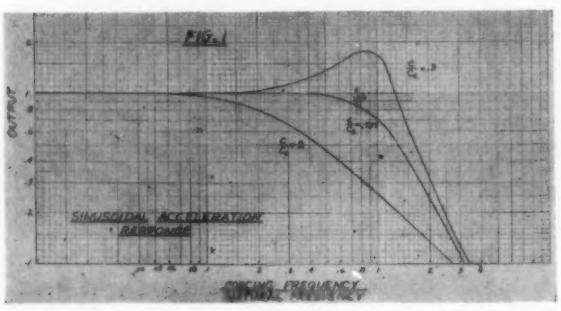
Two transducers used extensively for shock measurement on the sand drop machines are the unbonded strain gauge accelerometer and the diode tube accelerometer. To a lesser extent, various makes of crystal accelerometers have also been used, but certain deficiencies in frequency response impose severe limitations on their usefulness.

Limitations Noted

Due to the size and weight of physical elements necessary to produce the mass-spring system (an accelerometer represents a mass-spring system being excited below the resonant frequency), the strain gauge and the diode tube types both have definite high frequency response limitations. The crystal type, because of inherent capacitive coupling characteristics, has until recently presented problems in the low frequency response area.

The maximum flat frequency response that can be achieved with either the diode tube or strain-gauge type of accelerometer is about 1000 cps. This is based on a maximum obtainable undamped accelerometer resonance of 1500 cps, which, when viscously damped to .7 per cent of critical, results in a response that is flat to within 10 per cent up to 2/3 of the undamped resonance—or approximately 1000 cps.

Figure 1 depicts three response curves for accelerometers: the overdamped case, the underdamped case and 65 per cent of critical damping. Assuming identical resonant frequencies, the unamplified output sensitivity of the strain gauge is only about one-tenth of the diode tube unit, but it is considerably more reliable for transient measurement because of certain inherent problems relating to damping maintenance.



Both types are of limited value when steep wave fronts, such as saw-tooth forms, are being measured, since the fidelity of reproduction of such pulses depends on the ability of the transducer (and total system) to reproduce a multitude of high frequencies above 1 kc.

It is worth noting that both types respond to static acceleration measurement (DC). Since many shock testing techniques and specifications pertinent to the older sand drop machines require that a low pass filter be used in the monitoring system (100-250 cps), the high frequency response characteristics are of little value. This philosophy definitely does not apply when considering some of the newer saw-tooth specifications.

Results from New-Type Machine

Figure 2 depicts the results of reducing the high frequency cut-off point in a sequence of data recording a 6 millisecond, 100 g saw-tooth pulse as produced on a new type shock machine. This was accomplished by inserting a variable band pass filter into the circuit and varying

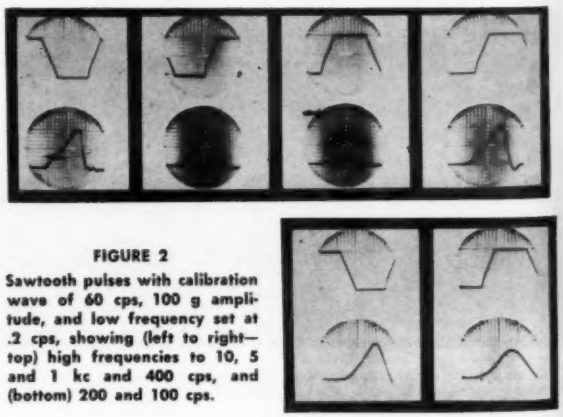


FIGURE 2
Sawtooth pulses with calibration wave of 60 cps, 100 g amplitude, and low frequency set at .2 cps, showing (left to right—top) high frequencies to 10, 5 and 1 kc and 400 cps, and (bottom) 200 and 100 cps.

The missile age and its phenomenal demands for environmental reliability have changed shock testing from a hasty qualitative operation to a carefully executed and carefully measured quantitative technique. Precision units designed specifically to produce controlled, repeated wave forms are supplanting older types; and considerations of sensitivity, dynamic range, frequency response and noise level have become extremely important.

the high cut-off frequency from 10 kc to 100 cps in six steps. The negative slope of the pulse terminating edge decreases as the cut-off frequency is decreased, and the peaking effect becomes markedly less, finally resulting in an almost sinusoidal wave form. The results were obtained with a crystal-type accelerometer with the proper cathode follower, variable band pass filter and a wide range oscilloscope.

Results are somewhat exaggerated by utilizing a filter as the frequency limiting instrument rather than accelerometers of varying natural frequencies, since the filter has a rejection rate of 24 db/octave compared with the 12 db/octave rate of an accelerometer above the resonance. However, the impracticality of having a multitude of accelerometers of varying natural frequencies necessitated use of the filter technique. The good low frequency response characteristics of these pick-up types eliminates the phenomenon of "undershoot" distortion, while a second advantage of the diode tube type of unit is that the output sensitivity is relatively high.

Range, Sensitivity Important

The dynamic range and output sensitivity of any accelerometer is extremely important. In general, when comparing like types of accelerometers, the higher the sensitivity the lower the natural frequency and the lower the value of peak acceleration that can be measured without physically damaging the pickup. A good rule of thumb in estimating frequency response and sensitivity is that sensitivity is inversely proportional to the square of the undamped natural frequency or,

$$\frac{S_1}{S_2} = \frac{f_{n_2}^{\ 2}}{f_{n_1}^{\ 2}}$$

where S_1, S_2=sensitivity—volts/g, and f_1 f_{n2}=undamped natural frequency.

Thus, it is not only important that the proper parameters of natural frequency and maximum allowable acceleration for a given pickup be known, but that the output sensitivity be of sufficient magnitude, depending on amplification, to allow reasonable signal resolution. Obviously, measuring 10 g's with a transducer whose output sensitivity was only 250 mw/g would result in only a 2.5 mv signal, which is hardly sufficient for proper monitoring resolution without additional system amplification. In this case the broad band instrumentation system noise level would greatly influence the minimum readable signal.

Following is a summary of the advantage and disadvantages of these pickup types in shock applications:

Diode Type. Advantages—relatively high sensitivity, DC response. Disadvantages—damping maintenance, lack of high frequency response, limited maximum value of peak acceleration.

Strain Gauge Type. Advantages—DC response, general reliability. Disadvantages—low sensitivity, lack of high frequency response.

The poor low frequency response of crystal accelerometers has, in the past, limited application to transient measurement. In addition, the inherent stray capacitive effects of dangling cables has caused severe signal fluctuations, often exceeding the actual transient being measured.

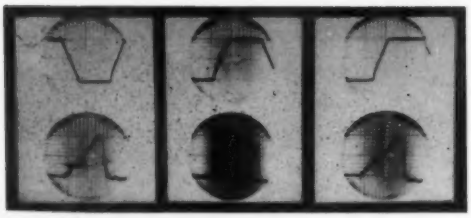
Cathode Follower

The necessity for using a cathode follower in conjunction with crystal type accelerometers is well known. Actually, the function of such a device is to provide an input impedance that is high relative to the output impedance (capacitive reactance at any frequency) of the accelerometer, since the impedance of crystals is usually quite high at low frequencies.

There are many different types of crystal transducers, all of which function by having dynamic stress cause a slight crystal reorientation, thereby producing a charge.

Lazarus

Maxwell Lazarus' basic engineering training was at Northeastern University, where he received a B.S. in mechanical engineering. He subsequently studied math and business administration on the graduate level and became a registered professional engineer in Massachusetts. From 1951-53 he was a vibration engineer engaged in the measurement and analysis of vibration, shock and sound for the Navy. He joined Barry Controls, Inc., Watertown, Mass., in 1953 and through 1957 his interests were the design, fabrication and testing of special isolation systems, dampers, shock machines and unit isolators. Since 1957 on he has been chief special project engineer in charge of all long range projects, including special shock machines, large isolation systems, special damping devices and other projects involving shock and vibration. He currently is in charge of all engineering quotations and proposals at Barry.



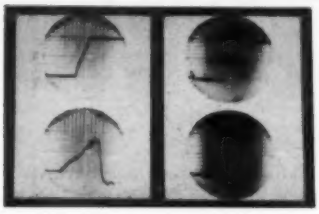


FIGURE 3

Sawtooth pulses with calibration wave of 60 cps, 100 g amplitude, and high frequency set at 10 kc, showing (left to right—top) low frequency cut-offs at .2, 1 and 2 cps, and (bottom) 5 and 10 cps.

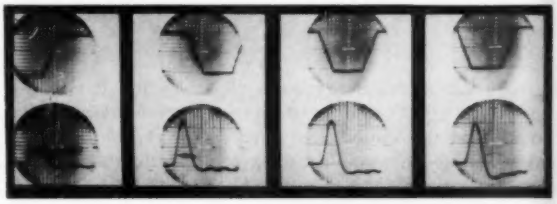
Rochelle salt, ammonium dihydrogen phosphate and barium titinate represent typical crystal compounds. Certain types have characteristics that provide advantages and disadvantages with respect to temperature range, sensitivity, etc., but all have excellent high frequency response relative to diodes and strain gauge types. Likewise, all suffer to some extent at the low frequency end of the spectrum. Therefore, the application of such accelerometers to shock measurement must be carefully considered.

A low frequency drop-off, occurring at too high a frequency, will result in an "undershoot," since the pick-up cannot resolve to a DC level from a finite frequency. Undershoot is always accompanied by a reduction in the magnitude of the voltage representing peak acceleration.

Figures 3 and 4 respectively indicate the results of limited low frequency response incurred during presentation of saw-tooth and half-sine wave forms as produced on a shock machine. The low frequency limiting parameter was obtained by use of band pass filter, and the various cut-off frequencies in each case are noted in the figures. The cut-off frequency points occurring on all the figures represent an amplitude of 3 db below the flat portion of the filter response.

Undershoot Is Evident

In both the saw-tooth and half-sine data, the apparent undershoot with the associated reduction in peak acceleration is quite evident. The higher the low cut-off frequency, the greater the undershoot and the lower the magnitude of peak acceleration. *Figures 5 and 6* represent a plot of reduction in peak acceleration vs. a ratio indicating



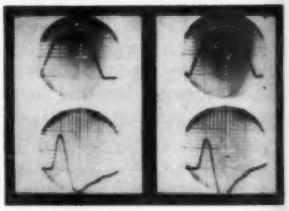
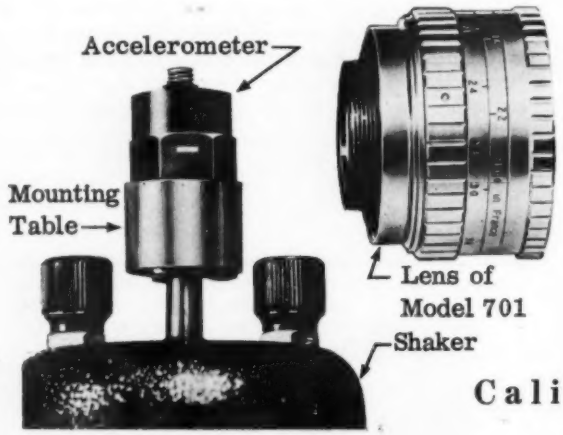


FIGURE 4

With calibration wave of 60 cps, 100 g amplitude, and high frequency set at 20 kc, half-sine, low frequency cut-off is varied (left to right—top): .2, 2, 5 and 10 cps, and (bottom) 20 and 30 cps.



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See the remarkable OPTRON Model 701 at the IES Show, Biltmore Hotel, Los Angeles, April 6-8.

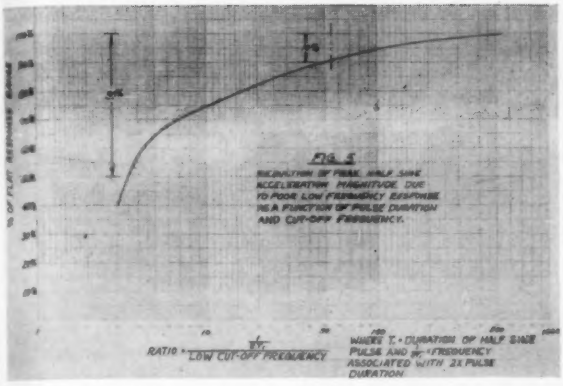
FIG. 5
REDUCTION OF PEAK HALF SINE ACCELERATION MAGNITUDE DUE TO POOR LOW FREQUENCY RESPONSE AS A FUNCTION OF PULSE DURATION AND CUT-OFF FREQUENCY.
RATIO = 1/T / LOW CUT-OFF FREQUENCY
WHERE T = DURATION OF HALF SINE PULSE AND 1/T = FREQUENCY ASSOCIATED WITH 2X PULSE DURATION

the relationship between the pulse duration and the cut-off frequency. While actually derived from *Figures 3 and 4*, this data should be equally applicable in dimensionless fashion to similar pulse forms of different absolute magnitudes and durations.

Also indicated: The shorter the pulse duration (or the higher the frequency associated with the pulse—quite arbitrary if a saw-tooth waveform is considered) with respect to the instrumentation low cut-off frequency, the less the general distortion and the less the reduction in peak acceleration.

For example (*Figure 5*), if no more than 10 per cent distortion of a .010 millisecond half-sine pulse were desired, the low frequency response of the instrumentation system (3 db or half power point) must not be above 1 cps. If the 3 db point were to occur at 28 cps, the peak would reflect a 50 per cent reduction.

This data is conservative since the error was based on a filter rejection rate of 24 db/octave, and in practice the low frequency fall-off of most instrumentation, including crystal pick-ups, is in the order of 6 db/octave.

Basic Problem of Crystal Pick-ups

The basic problem relative to crystal pick-ups is that the impedance of the crystal element is essentially capacitive, appearing high at low frequenices. It requires that an equally high (or higher) input impedance be provided in the next unit of instrumentation, usually a cathode follower. The frequency at which the two impedances are equal will represent the low cut-off or 3 db point. For calculation purposes the capacitive reactance of a crystal can be expressed as:

$$x_c = \frac{1}{2\pi fc}$$

where f=frequency in cps and c=capacitance in Farads.

(Continued on Page 46)

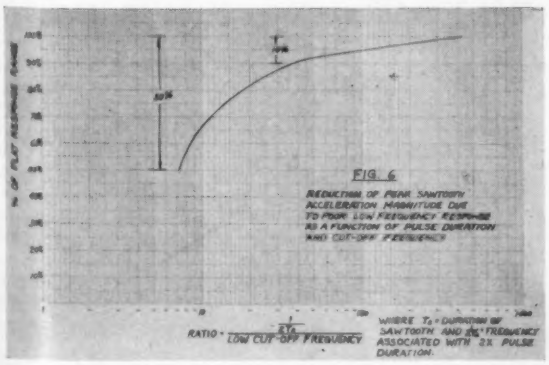
FIG. 6
REDUCTION OF PEAK SAWTOOTH ACCELERATION MAGNITUDE DUE TO POOR LOW FREQUENCY RESPONSE AS A FUNCTION OF PULSE DURATION AND CUT-OFF FREQUENCY
RATIO = 1/T / LOW CUT-OFF FREQUENCY
WHERE T = DURATION OF SAWTOOTH AND 1/T = FREQUENCY ASSOCIATED WITH 2X PULSE DURATION.

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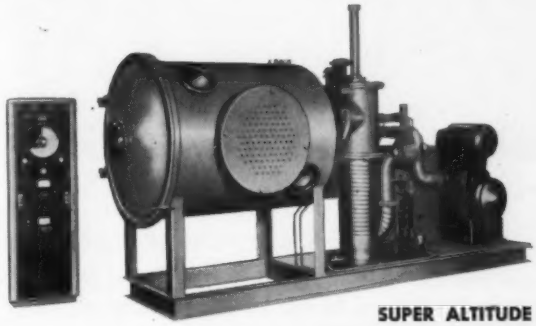

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Path of the Environment:

VIBRATION TESTING

Yesterday, Today and Tomorrow

As man grapples with the awesome complexities of the Space Age, the techniques and applications of high-power electronic vibration systems are reaching new levels of sophistication; for the end uses of these systems are now largely concerned with the ability of space vehicles and their components to withstand the severe vibrations encountered in certain phases of flight.

By Cameron G. Pierce
President
Ling-Altec Electronics, Inc.

AMONG THE DOZEN or more man-made or environmental hazards—including shock, acceleration, pressure, static electricity and radiation—to which space vehicles are subjected, vibration and temperature are regarded as the major sources of component failure. With the rapid increase in power, speed and complexity of missiles, rockets and jet aircraft, the requirements of reliability have made ground-testing of components and assemblies an imperative necessity.

The first vibration testing systems, developed in the immediate post-war period, were modest enough: small amplifiers driving primitive shakers that developed a peak force of but 5 pounds. To illustrate the dramatic progress that has been made in only a dozen years, one of the latest Ling systems employs a power generator rated at 175,000 va, coupled to a giant, 15-ton electromechanical shaker that delivers an output of 28,000 pounds-force. Even larger systems are now being designed, as prime weapons contractors and systems manufacturers develop larger and larger assemblies requiring testing equipment of higher and even higher force capacity. The newer missiles and aircraft involve higher levels of thrust and higher Mach numbers.

Specs Reach 3500 cps, 45 g

There is also a trend toward increased stiffness in structural design, and an increase in testing acceleration levels and frequencies is a logical result. Test specifications for some electronic equipment are now reaching 3500 cps and 45 g. This increase is expected to be general and may reach frequencies of 5000 cps and acceleration levels of 60 to 80 g.

Acoustic testing is also becoming an increasingly important factor in vibration testing. It offers certain advantages in reaching frequencies above the limits of electromechanical systems, and can apply the desired frequency force simultaneously to all surfaces of the test object.

Three basic systems can meet all existing acoustic testing requirements:

(1) Reverberation chambers, where large specimens (2 to

Pierce

The names of Cameron G. Pierce and of Ling-Altec Electronics, Inc., are among the most exciting in modern electronics. As co-founder and vice-president of L. M. Electronics, predecessor to Ling, Pierce designed and developed the company's basic line of high-power electronic products. Before that he was chief engineer for the American Broadcasting Company's western division and development engineer, working on radar and other high-power equipment, for General Electric. He has acted as consultant to the Rockefeller Foundation and the Fund for Adult Education of the Ford Foundation. He holds an A.B. in electrical engineering and E.E. in communications engineering, both from Stanford.

10 cubic feet) are placed within the chamber and subjected to a build-up of sound pressure levels from continuous reflections over extensive periods.

(2) Plane wave tubes, for testing small components or parts at high sound-pressure levels from a relatively low-energy source.

(3) Exponential horns with electro-pneumatic transducers for large apparatus or complete airframes where tests must be conducted under free-field conditions.

Another area of increasing importance for the newer, high performance rockets, missiles and jet aircraft is combined environmental testing. To fully determine operational results of pre-flight testing, it is necessary to establish the effects of temperature, vibration, altitude and other environmental conditions in their various combinations.

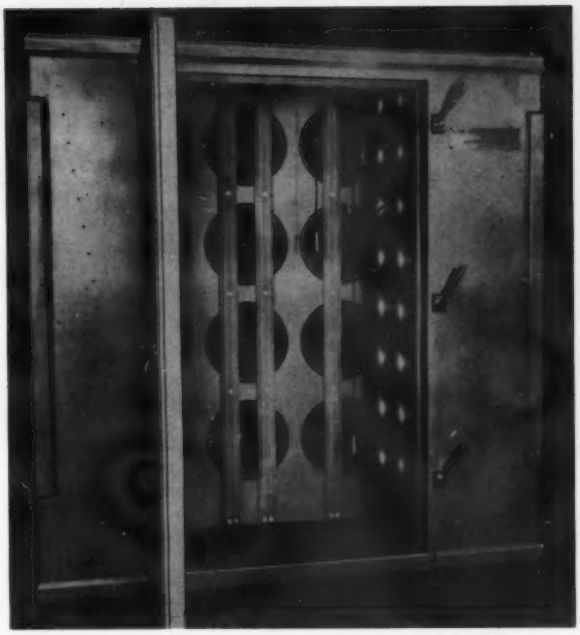
More Combined Environments

Some design refinements are needed to exploit fully the use of combined environmental testing. But to illustrate its importance, temperature-vibration testing is expected to increase from about 5 per cent of the total vibration test load to approximately 50 per cent within two years. This requires new shaker designs capable of operation within these environments.

As the emphasis on reliability has increased, testing specifications logically have been extended to production testing of components, sub-systems and systems. More manufacturers are utilizing small, economically priced vibration systems with capabilities from 25 to 500 pounds-force. Compact, fully packaged systems (like the Sine-O-Matic series for automatically programmed sine wave testing and the Randomatic series for random wave production-line testing) permit pushbutton operation by production personnel, under the supervision of laboratory specialists.

In addition, there is a strong trend toward the greater use of random and complex wave excitation in the new missile programs. Recent technical "breakthroughs" include the spectral density equalizer/analyzer system for continuous and parallel observation and control of test spectrum in random wave test programs.

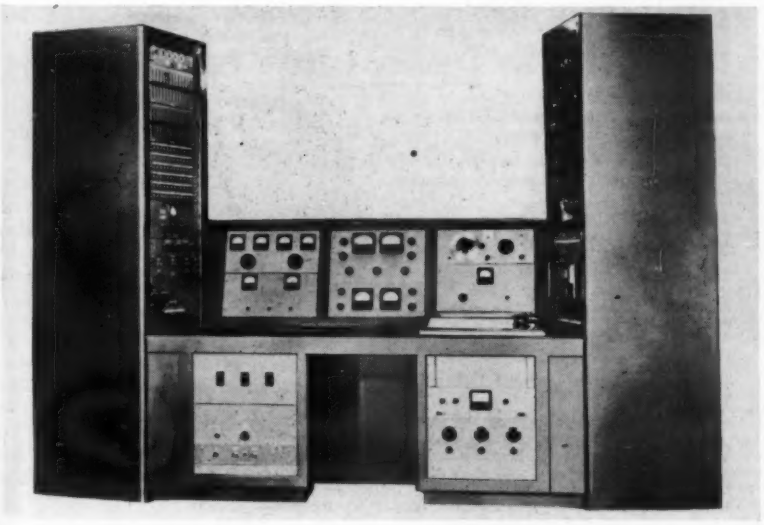
As environmental test problems increase in severity, the greater will be the requirements on the design engineer to produce vibration exciters to satisfy the new requirements. Present day shakers can be operated as an integral part of an environmental chamber. New features include thermal barriers, liquid cooling systems, protection from metal fragments and ability to withstand wear under rigorous use.



Reverberation chamber for acoustic testing of large specimens.

The markets for environmental test equipment are expanding beyond the air frame and missile industry. Automotive and transportation companies acknowledge the values of environmental test equipment to improve the design and production of tomorrow's vehicles.

We are at the threshold of an entirely new scientific concept that is limited only by the scope of the environmental engineer's imagination.



Ling's "Randomatic" system was designed for production line testing of components.

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RADC Lab Chief Joins Itemlab

John M. Thompson, for the past 10 years laboratory chief of the test facilities laboratory, Rome Air Development Center, has become vice president and general manager of Itemlab, Inc., of Port Washington, N. Y. Thompson spent 25 years in government service before switching over to private business.

Varian Elects Cary

Howard Cary, president of Applied Physics Corp., Monrovia, Calif., has been elected to the board of directors of Varian Associates, Palo Alto, Calif. Cary, a prominent scientist, is an authority on electronic instrument design and application.

* * *

STANLEY C. SWANSON has been appointed sales engineer at ACTON LABORATORIES, INC., Acton, Mass., with responsibility for sales of ALI measurement and control instrumentation and components in eastern regions. He is an Iowa State alumnus.

* * *

ROBERT GOLDSMITH has been promoted to manager of contract engineering at ASSOCIATED TESTING LABORATORIES, INC., Caldwell, N. J. An aeronautical engineering graduate of New York University, he previously had represented ATL in the greater New York area.

* * *

H. P. PETERSON, formerly chief engineer for air conditioners and military ground support equipment at Recony Corp., has joined the Refrigeration, Heating and Air Conditioning Products division of TENNEY ENGINEERING, INC., Union, N. J., as sales engineer.

* * *

GLEN R. LARSON, a graduate of Illinois Institute of Technology and a member of ASTE and ASME, is new on the sales engineering staff of the Oakland, Calif., headquarters office of THE RUCKER COMPANY. He was formerly with Hydraquip Corp. as branch manager and with United Machine Co. as chief engineer.

CHESTER C. VINCENTZ, JR., recently of IT&T's Federal division, has moved over to SPACE-TRONICS, INC., Mineola, N. Y., sales representatives, as sales engineer specializing in environmental equipment. He is a graduate of Stevens Institute.

* * *

JOHN A. SLATTERY is the head of MARTIN CO.'s newly established Baltimore Electronics division. All other engineering in Baltimore is under the new Weapons System division, headed by **HERMAN PUSIN.** The changes follow a reorganization of the old Baltimore division.

* * *

WILLIAM C. PARKHURST is now in charge of the Ordnance Research Environmental Laboratory (Qualification & Evaluation Lab) of LOCKHEED's Missiles and Space division at the Santa Cruz test base. He was formerly with Chrysler Corp.

* * *

CHARLES W. ("Chuck") AVERY has been appointed machinery mount field engineer with BARRY CONTROLS' western division at Glendale, Calif. He joins the nationally known manufacturer of mounting systems for industrial machinery from the Die Supply division of E. W. BLISS Co., where he was industrial sales engineer.

* * *

LINCOLN VAN CAMP has been named vice president-production for the WYLE MANUFACTURING CORPORATION, El Segundo, Calif., as part of the company's major expansion in plant area and personnel.

* * *

DUANE C. MANNING, formerly sales manager of Fairchild Controls Corp. West coast division, has been appointed manager engineering sales in the Pacific area for INTERNATIONAL RESISTANCE CO., Philadelphia.

Cusack Heads Pure Carbonic

G. C. Cusack, executive vice president of Pure Carbonic Company, New York, a leading producer of liquid, gaseous and solid CO_2, has been named president. He succeeds J. J. Lincoln, Jr., who has moved over to the executive staff of Pureco's parent company, Air Reduction Company.

* * *

ARTHUR A. BRIGGS has been named customer liaison engineer in the expanded Environmental Testing division of ACTON LABORATORIES, INC., Acton, Mass. He has been connected with environmental testing and with New England electronics and industrial firms for the past 10 years.

* * *

WARREN R. BARTON and **L. BRUCE DARLING** have been named to two new posts in the CONSOLIDATED VACUUM CORPORATION staff realignment at the Rochester, N. Y. plant. Barton, CVC purchasing agent for the past six years, becomes manager of the material and production control department; and Darling, CVC plant engineer since 1953, becomes manager of the industrial engineering department.

* * *

DR. LAWRENCE W. VON TERSCH, head of Michigan State University's electrical engineering department,

Cusack

Briggs

Barton

Gerhard

Larson

Darling

has been elected president of the NATIONAL ELECTRONICS CONFERENCE to be held in Chicago this fall. Other officers are: executive vice president, **JOSEPH J. GERSHON** (DeVry Technical Institute); secretary, **JAMES H. KOGEN,** (GPE Controls, Inc.); treasurer, **DR. HAROLD E. ELLITHORN** (Notre Dame); asst. treasurer, **ROBERT J. PARENT** (U. of Wisconsin). **WILLIAM O. SWINYARD,** vice president of Hazeltine Research, Inc., is chairman of the NEC board.

* * *

JAMES R. CAPELLI, New Haven; **JOSEPH A. SILVESTRO,** Chicago, and **DENNIS C. LYNCH,** Los Angeles, are regional field service managers recently appointed by MB ELECTRONICS, a division of Texton Electronics, Inc.

* * *

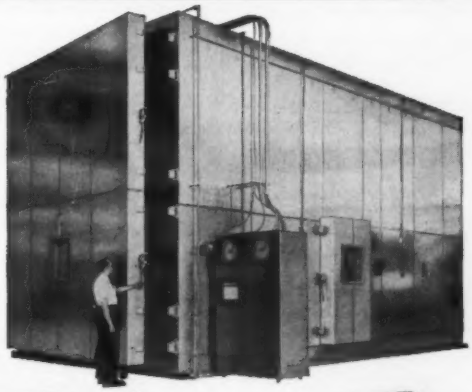
EDWARD F. TALBOT has joined EQUIPMENT SALES COMPANY, INC., New Haven, as a field sales engineer and will work out of the Boston area branch office at Danvers, Mass. The company specializes in environmental testing equipment and related instrumentation.

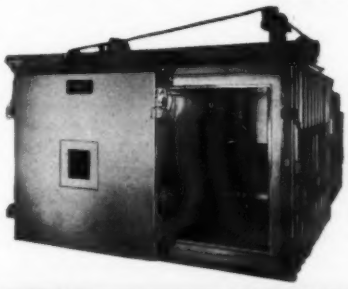
* * *

SIDNEY GERHARD is the new chief engineer at PROPULSION TEST FACILITIES, a division of MB Electronics. He held a similar post previously with Test Equipment division, Consolidated Diesel Electric Corp.

AR★

The most advanced testing techniques are being built into American Research equipment right now!





◀ Altitude, Temperature Humidity walk-in chamber 10′ high x 8′ wide x 12′ deep interior with push-button door controls inside and out.

Altitude chambers in any ▶ size — Altitude 200,000′ or higher; temperature +500°F and higher to −100°F and lower; Humidity 20% to 95%.

▲ Prefabricated Temperature and Humidity walk-in test facility with test space 12′ x 25′ x 15′ high.

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LITERATURE FOR ENVIRONMENT...

Associated Testing Laboratories, Inc., Caldwell, N. J., gives a quick rundown on its off-the-shelf environmental test chambers and equipment in a two-page, two-color catalog. Included are acoustic-noise test systems, auxiliary vibration (slippery) tables, and saw tooth shock machines. **(Circle EQ RSC #38)**

* * *

Barry Controls, Inc., Watertown, Mass. has a beautifully printed bulletin outlining its many capabilities in the rapidly-advancing field of shock, vibration and noise. The bulletin demonstrates solutions to isolation problems and illustrates the company's wide range of modern research, production and testing facilities. **(Circle EQ RSC #39)**

* * *

Unholtz-Dickie Corporation, Hamden, Conn., gives dimensions and description of its 400 lb. force shaker in a new bulletin on Series 70 vibration test systems. System performance, components and accessories are covered. **(Circle EQ RSC #40)**

* * *

Jan Hardware Mfg. Co. Inc., Long Island City, N. Y. describes its four Jolta models for impact shock testing in a four-page bulletin. Engineered to reproduce the entire spectrum of significant shock waves, the machines range from bench models to 12-ft. testers handling 200 lbs. and 2-ft. cubes. **(Circle EQ RSC #41)**

* * *

Hastings-Raydist, Inc., Hampton, Va., has a four-page folder on the various models of Hastings Air-Meters. Activated by compensated heated thermopiles, the meters range from battery operated hand models up to instruments that record 200 mph air movement. **(Circle EQ RSC #42)**

* * *

Lourdes Instrument Corp., Brooklyn, has published an attractive blue and gold illustrated 16-page catalog of 13 models of its superspeed centrifuges. The models have rotor capacities up to 3,000 ml and speeds up to 18,000 rpm, with some developing relative centrifugal force of 27,000 x g. **(Circle EQ RSC #43)**

* * *

Vap-Air, Chicago, lists its three standard merc thermostat groups in an 18-page catalog. The new line features lower cost and 30-day delivery. The groups: well-type for sensing case temps, duct-type for gas or fluid sensing, and surface-type for area contact such as in anti-icing systems. All meet military specs and come complete, ready to mount. **(Circle EQ RSC #44)**

Government Publications

Almost daily the U. S. Department of Commerce releases a number of technical reports for use by industry. These documents are sold through the department's Office of Technical Services, Washington 25, D. C. Here are some recent releases and their prices:

(ONR—Office of Naval Research)
(WADC—Wright Air Development Center)

Investigation of Design Criteria for Cushioning Materials, by S. M. Krakover and A. Olevitch, WADC. Air Force research giving an engineering basis for the proper and economical selection of cushioning materials. Discusses acceleration-static stress curves, static stress-strain and creep characteristics. 34 pages. Order No. PB 151720, $1.

Arthur S. LaPine & Company, Chicago, offers a four-page, two-color bulletin on the West German Leybold rotary gas ballast vacuum pumps on which it recently assumed distributorship. Performance and pump-down time at reaching high altitude conditions are shown on graph curves for several models. **(Circle EQ RSC #45)**

* * *

Consolidated Electrodynamics Corp., Pasadena, Calif., describes its Type 5-114 recording oscillograph in a 16-page illustrated brochure. Evaluation by dynamic testing and the special features of 18 and 26-channel oscillographs for precise recording of both static and dynamic data are among the subjects covered. **(Circle EQ RSC #46)**

* * *

Tempo Instrument Inc., Hicksville, N. Y., presents complete technical data on its line of adjustable electronic time delay relays in an 8-page catalogue. Circuits, design, specifications, applications and sizes are described. **(Circle EQ RSC #47)**

* * *

Conax Corporation, Buffalo, N. Y., gives complete details on its line of mineral insulated thermocouples in a 20-page catalog. The catalog, punched for ring-binding, describes rates and a unique ordering system for more than 24,000 assembly combinations from a factory stock. **(Circle EQ RSC #48)**

* * *

Ultradyne, Inc., Albuquerque, variable reluctance and DC-DC type pressure instrumentation is described in a four-page brochure. **(Circle EQ RSC #49)**

Study of Vibration and Shock in Aircraft and Development of Instrument Mountings: Interim Report No. 1, by E. H. Fey and R. O. Loving, Armour Research Foundation of Illinois Institute of Technology. Military specifications are too high for the amount of shock and vibration flight control instruments must withstand, this report finds. The central and forward fuselage sections of aircraft have much less severe vibration levels than test levels established by MIL-E-5272A, except for locations near propellers and guns, it says. 72 pages. Order No. PB 151540, $2.

Human Engineering Bibliography: 1956-1957, by Tufts University for ONR. One of a planned series of annual bibliographies of literature pertaining to human engineering. Selected to cover a wide variety of interests of human engineers, from symposiums, publications and other sources. 369 pages. Order No. PB 131-507-S, $5.

Corrosion Prevention, by Office of the Chief of Civil Engineers, Navy Bureau of Yards and Docks. A Navy manual on the most practicable methods and materials for controlling or minimizing corrosion. Data on atmospheric, submerged and sub-surface corrosion and on alternately wet and dry areas. Corrosion discussed include dissimilar metals, direct chemical attack, stray currents and microbiological. 431 pages. Order No. PB 151756, $6.

Methods of Flight Vehicle Noise Prediction, by P. A. Franken and E. M. Kerwin Jr., Bolt Beranek and Newman, Inc., for WADC. A design manual for aeronautical engineers to predict accurate noise levels with aircraft of different configurations before actual flight testing. Includes basic noise-transmitting properties of panel structure, effects of coincidences, resonances and damping. 191 pages. Order No. PB 151827, $3.

Heat and Mass Transfer Bibliography with Selected Abstracts, by W. J. Christian and T. H. Schiffman, Illinois Institute of Technology for WADC. A bibliography and selected abstracts of literature on the general problem of heat and mass transfer. Contains three sections dealing with mass transfer from surfaces under isothermal and non-isothermal conditions, heat transfer from airfoil surfaces and correlations between heat and mass transfer. 172 pages. Order No. PB 151517, $3.

Energy Dissipation in Longitudinal Vibration, by C. S. Chang and L. E. Goodman, University of Minnesota, for WADC. Research and solution of the problem of longitudinal vibrations in a finite prismatic bar with a terminal viscous damper. Examples given of the applications of the general solutions, and the amount of mechanical energy dissipated through the damper is computed. 47 pages. Order No. PB 151312, $1.25.

Notes of Firms In the Environs

Environmental Miscellany . . .

Air Reduction Company, New York, sales last year hit a record $200 million, up 14% over 1958 . . . Varian Associates, Palo Alto, Calif., announced record sales and earnings for the first fiscal quarter ending Jan. 2—$10½ million sales and $775,000 earnings, increases of 30% and 44%, respectively, over the comparable 1958-9 quarter. The company has a $25 million order backlog.

Barry Also Sets Records

Barry Controls, Inc., reported record sales and earnings for 1959 and predicted 1960 sales will top $7 million. Last year's figures: $5,686,000 sales; $409,000 net earnings . . . Barry gave its employees a 3 per cent across-the-board wage increase and also began a new pension plan with the start of the new year. The pension plan, paid wholly by the company by an allocation of 10 per cent of profits before taxes, supplants the present profit-sharing quarterly cash bonuses, estimated to total 7 per cent of annual profits.

Wyle Acquires Parameters, Inc.

It's Wyle-Parameters, Inc., now with the acquisition of the New Hyde Park, N. Y., testing firm by Wyle Laboratories, of El Segundo, Calif. Management of Parameters, headed by Roger Amorosi, remains to undertake a major expansion program.

Conrad, Blue M Expand Services

Conrad, Inc., Holland, Mich., chamber manufacturer, has established direct factory engineering services in the Washington-Baltimore area. Denver Armstrong is the field application engineer at the other end of telephone number DIstrict 7-2696 . . . Blue M Electric Company, Blue Island, Ill., has established a new office at 2312 South Main St., Los Angeles—the Blue M Engineering Company—to offer technical and sales service for its industrial and environmental temperature controlled equipment. James O. Reece, senior engineer and physicist, heads the office.

Lockheed Electronics Equipped

Space-Tronics, Inc., Mineola, N. Y., has installed three Guardite Co. environmental chambers and an L.A.B. vibration table at Lockheed Electronics Corp., Plainfield, N. J.

The chambers are an 8'x10'x8' walk-in temperature-humidity room, a 6'x6'x6' temperature-altitude-humidity chamber and a 4'x4'x4' temperature-humidity cabinet. The L.A.B. table is six feet square and handles 5,000 pounds at 10 g.

VACION® Pump now available in a complete system

used for evacuating and processing products requiring clean, ultra-high vacuum such as vacuum tubes and semiconductor products. The Varian #V-10738 system includes a 40 liter/second Vacion Pump, a bake-out oven and controller, pressure gauges, roughing pump, and necessary power supplies in a convenient console "package." This spares your engineering department the trouble and expense of becoming ultra-high-vacuum specialists in order to make one installation (or just a few).

Varian systems are built around the revolutionary electronic Vacion Pumps which provide ultra-high-vacuum without use of fluids, moving parts, or hot filaments. They are totally free from contamination sources and will operate completely unattended. The total system is all metal and has been carefully engineered by Varian's high-vacuum specialists to the same high quality as the Vacion Pump itself.

Where a standard system does not solve your problems completely, Varian will design a custom system for your specific needs. For customers desiring to engineer their own systems, Varian furnishes Vacion Pumps and system components separately as desired, with pumping speeds of 1 liter/second to 10,000 liters/second.

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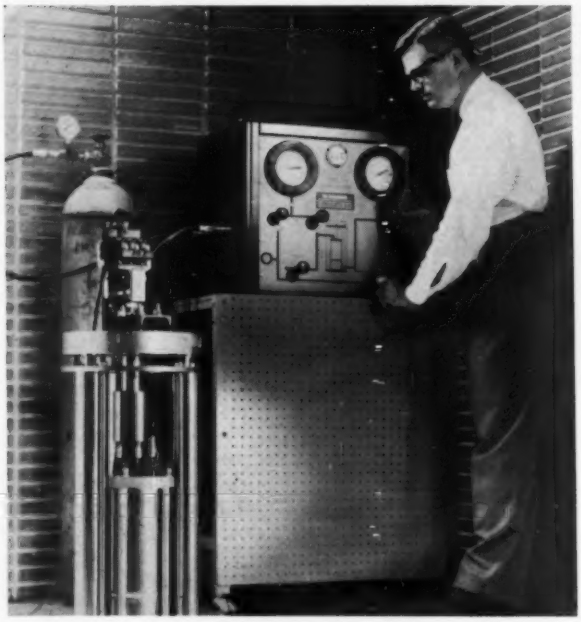
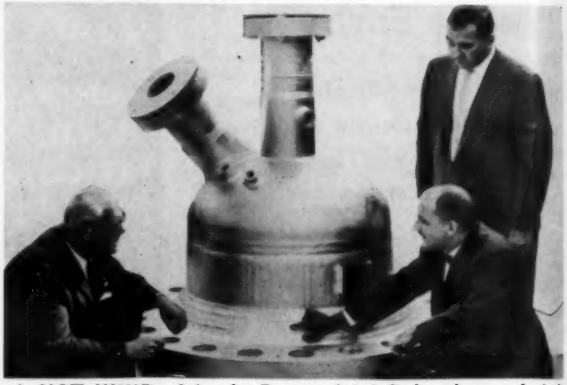
Environmental Quarterly's Album of People, Products, Places and Ideas...



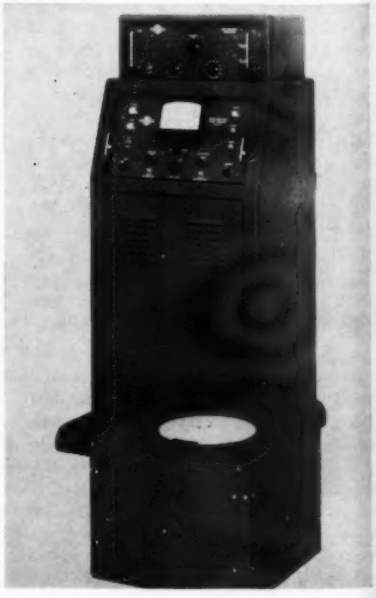


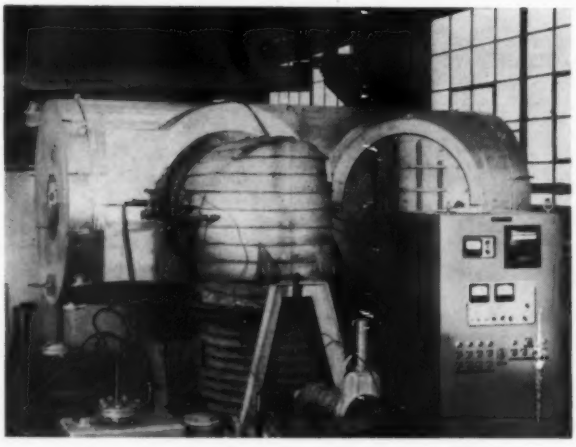
A HOT WIND—John L. Brown (at left in above photo) and George E. Sutila also kneeling), both of Douglas Aircraft's Aerophysics lab, and David Johnson, of Hirt Combustion Engineers, examine Hirt's 10-million BTU/hr pebble heater burner to heat air in the lab's 27-inch wind tunnel from 300° to 3,500° F. (Circle EQ RSC A).

AT THE SHOW—Visitors to the IES show in Los Angeles next month will see Consolidated Vacuum Corp.'s new HY-6500 shock tester (left), as well as a CVC set-up, with such new components as a liquid N_2 baffle, for attaining ultra-high vacuum. (Circle EQ RSC B).

BOIN-N-N-N-G NO MORE—Ervin Pietz (at right in photo at left), president, and Jerome Ruzicka, R&D engineer, of Barry Controls, demonstrate resonant vibration in a conventional aluminum beam and the lack of same in one of Barry's new damped beams (See Page 8 or Circle EQ RSC C).

ANOTHER STAR—Among several Micro Gee Products, Inc., entries at the IES show will be the Model 60A oscillating rate table (below) for rapid frequency response testing of rate gyros and angular accelerometers. It takes loads to 100 lbs. (Circle EQ RSC D).



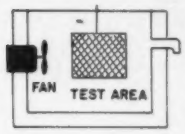


WAY-UP — This NRC Equipment Corp. chamber (left) has reached pressures below $5x10^{-9}$ mm. Hg., and may go lower. It is 4' across and 100" long. IES visitors will see the chamber's 32" pump and its Nottingham gauge (Circle EQ RSC E).

here's 4 ways CARDOX® CO_2

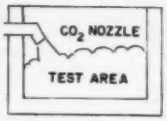
can help you achieve versatile... fast... low cost BELOW 0°F. ENVIRONMENTAL TESTING

1 dry ice chamber



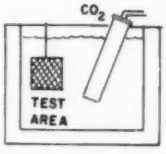
Simple, easy, inexpensive. A fan blowing over a wire basket full of crushed dry ice will reduce chamber temperatures from 0 to —70°F. A quick, low cost method for making occasional or isolated cold tests.

2 direct discharge of liquid CO_2



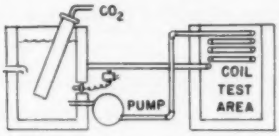
Easiest, most efficient method for consistent, cold testing in production operations. Bulk liquid carbon dioxide is discharged directly into the test chamber. You get controlled test conditions from 0 to —100°F. in 60 seconds or less. Best of all, one CO_2 storage tank can serve a battery of test chambers.

3 immersion tank method



For low cost production-line cold testing. Crushed dry ice or bulk liquid CO_2 is injected into an acetone, methanol or trichlorethylene base solution. Items to be tested are immersed in the slurry which has a temperature of minus 109°F. An ideal method of making cold "shock" tests.

4 indirect cooling method



Bulk liquid CO_2 is discharged directly into refrigerant line or surge tank containing acetone, methanol or trichlorethylene type solution. Refrigerant is then pumped thru test chamber to reduce temperature by means of coil-type heat exchanger. Major advantage—no CO_2 atmosphere in test chamber . . . an important factor where this condition is not desirable.

This exclusive feature can save you up to 15%
CARDOX® PATENTED RE-CYCLING SYSTEM keeps Liquid CO_2 COLDER . . . minimizes vapor loss

Low pressure liquid Carbon Dioxide storage tanks are located some distance from the point of use. Heat in the piping may vaporize a part of the liquid CO_2 so that vapor as well as liquid CO_2 arrives at the nozzle. This is undesirable for several reasons.

1. The vapor has reduced refrigerating effect and results in a loss of CO_2.
2. The vapor causes intermittent discharge; discharge rate and control is affected.
3. Starting may be delayed as large amounts of vapor must be discharged before pipe cools sufficiently to eliminate creation of vapor.
4. Vapor discharge can interfere with temperature control accuracy.

The exclusive Cardox Re-Cycling System eliminates these disadvantages.

Float valve just prior to the nozzle separates vapor from the liquid CO_2. A vapor pump connected to a return line pumps the vapor back to the storage tanks.

The new Cardox Re-Cycling System means greater efficiency, control and economy for users of bulk liquid CO_2 systems.

CARDOX systems can be engineered to provide temperature ranges from 0 to —150°

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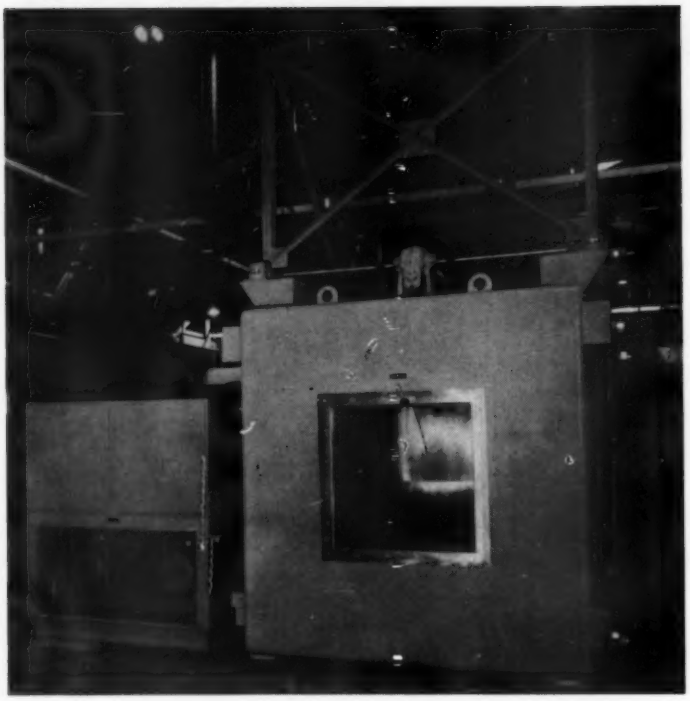
CHEMETRON



Temperature (—120° to +125° F.)—altitude (100,000')—humidity chamber designed by the author for Murphy & Miller, Inc., has 216 cubic feet and automatic self-elevating door.

by Paul H. Brandt
General Manager, Manufacturing Division
Murphy & Miller, Inc.

Moisture and Altitude Don't Mix

Out-gassing and evaporation of moisture in altitude chambers are often mistaken for leaks in the shell. A thorough understanding of these troublesome factors will save many hours of fruitless checking. Out-gassing and evaporation also place certain limitations on the design of altitude chambers.

THE ADDITION OF A HUMIDITY CYCLE in an altitude chamber may, on the surface, appear to be a logical way to economize on environmental test equipment. But if all of the facts are taken into consideration, it can be a very costly accessory.

An altitude chamber is not an inexpensive facility. A humidity test chamber designed for a temperature range of +35° F. to +200° F., and available with a 0° F. cycle, can be purchased for a fraction of the cost of the simplest form of altitude-temperature chamber.

Humidity tests usually require long periods of time. When an altitude chamber is used for such tests, a very expensive piece of equipment is being tied up for something that can be done separately in a comparatively inexpensive unit. Proper planning of future programs can easily provide justification for the initial cost of separate humidity and altitude test chambers. One argument against two chambers is that they require extra floor space in the laboratory, planning of test facilities should include adequate floor areas.

Vapor Expands to Astronomical Volume

In analyzing the problems of operating an altitude chamber equipped with a humidity cycle, one needs merely to consult a standard steam table to discover that the evaporation of water and water vapor, as the pressure within the chamber is reduced, constitutes an astronomical volume to be evacuated before high altitude conditions can be reached.

Water at sea level pressure boils at +212° F. As the pressure on any water or water vapors left in a chamber is reduced, the boiling or evaporating temperature of the water is reduced until at 8 mm. Hg. (100,000 feet altitude) water is evaporating at approximately 47° F. In

(Continued on Page 28)

LOW COST CENTRIFUGE

for large-quantity acceleration test programs

Genisco Model A903 features simplified operating procedures; rugged construction...for fast, accurate testing to MIL-E-5272A, Procedure II

Although the A903 is a simple, low cost centrifuge, it has many features found in more sophisticated machines, *plus* unique features which particularly suit it for production-line testing and evaluation programs.

SIMPLE OPERATION—Except for an on-off switch, controls are limited to a single handwheel which controls table speed. Chance of human error is reduced to a minimum. Test personnel can learn its operation in minutes.

SPEEDS TESTING—24" diameter mounting-table will accommodate several test objects. Arranged symmetrically, they can be subjected to acceleration forces simultaneously.

RUGGEDLY-BUILT—Virtually immune to operational abuse. Will operate for long periods without maintenance as demanded for production test programs.

0.5% ACCURACY—Constancy of rotation of the mounting-table is within 0.5%, including wow and drift. Table rotation speed can be measured electronically within ±1 count.

BRIEF SPECIFICATIONS

G-Range: 1 to 1,000 g's in five standard ranges, infinitely variable

G-Pound Capacity: 2,500 g pounds, maximum

Constancy of Rotation:

Wow: 0.5%, maximum

Drift: 0.2% of rate per minute, maximum

Speed Indication Accuracy:

Tachometer: ±1¼%

Magnetic Pickoffs: 60 tooth pickoff gear standard; 600 tooth gear optional. Pulses are fed to a front panel coaxial receptacle for use with any standard electronic counter.

Vibration Isolation: 0.1 g in any plane, at any speed

Test Object Dimensions: 8" high (24" diameter circular platform)

Slip Rings: 8 standard, 10 amp. maximum

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other words, if the temperature in the chamber is above 47° F., the heat in the chamber will cause the water to boil or evaporate.

At sea level pressure and +212° F., water expands approximately 1,600 times its volume in changing from a liquid to a vapor or steam. At 8 mm. Hg. water expands approximately 122,500 times its liquid volume when evaporating. This is very advantageous in the design of a steam engine, but it presents a mammoth pumping problem in an altitude chamber. As the pressure in the chamber is reduced to 4.5 mm. Hg., the boiling or evaporating temperature of water is reduced to +32° F., which is, of course, the freezing point of water.

As the pressure in the chamber is further reduced, any water left in the chamber turns to ice. If the surrounding temperature is above the melting point, this ice evaporates and continues to expand, and must be removed by the evacuating system of the chamber.

'Sublimation' Phenomenon

Evaporation of ice to a vapor without first changing to a liquid, is known as "sublimation." In the chamber the evaporating or sublimation temperature of any ice left is reduced as the pressure is reduced. At 250,000 feet altitude (17 microns) sublimation occurs at approximately —70° F.

A pound of water occupies .016022 cubic feet of space. In evaporating at 4.5 mm. Hg. this expands to 3304.5 cubic feet of vapor, and the vapor must be removed from the chamber before satisfactory altitude performance can be obtained.

If this were the only problem, there still would not be too much trouble in obtaining a high vacuum if given sufficient time for evacuation, or if the capacity of the vacuum pumping system were increased. However, moisture condenses in the oil of the vacuum pump, causing further difficulty. The addition of a gas ballast on the vacuum pump helps reduce pump moisture, but it also decreases pumping efficiency and lengthens evacuating time.

Brandt

Paul H. Brandt, who recently became manager of the environmental products division of Chicago's Murphy & Miller, Inc., is an old hand in the refrigeration business. A 1940 graduate of the Refrigeration and Air Conditioning Institute, Chicago, he was also graduated in 1948 from the York Institute of Refrigeration, where he received highest honors. He holds several patents covering low temperature cascade refrigeration. He is a member of the American Society of Air Conditioning and Refrigeration Engineers and of the Institute of Environmental Sciences.

Refrigerated Trap Available

The operator of an altitude chamber equipped with a cascade refrigeration system has available a built-in refrigerated trap. This trap acts as a vacuum pump in freezing out any condensable gases before they enter the pumping system, and in holding them in the form of ice below their sublimating temperature.

When operating an altitude chamber in the higher altitude ranges (above 90,000 feet), whether equipped with humidity or not, the refrigeration system should be used to freeze out the moisture which may be left in the chamber and keep it out of the pumping system.

By intelligent use of the refrigeration system of an altitude chamber large volumes of condensable gases can be handled without appreciably affecting the speed of the vacuum pump. To hold any ice formation and keep it from sublimating or evaporating, the temperature of the ice must be kept well below its sublimation or evaporating temperature. However, untold difficulties have been experienced in obtaining high vacuum conditions—especially when a humidity cycle is included in an altitude test chamber. This usually is due to the operator's lack of knowledge of the moisture and out-gassing problems.

Freeze-Out System A Must

If a humidity cycle is included in a chamber designed to simulate these higher altitude conditions, the chamber must be equipped with a separate freeze-out system to remove all traces of moisture before it enters the pumping system. Because of the complexity of an automatic freeze-out system and/or operator failure to follow instructions, a system of this type is not recommended unless the out-gassing and moisture problem is thoroughly understood by the operator.

The following pressure-temperature relationships may be used as a guide to the required coil temperature to keep moisture from entering the pumping system:

Mercury	*Approx. Alt. (feet)*	*Evaporating Temp. (F.)*
8 mm.	100,000	47°
4.5 mm.	115,000	32°
1 mm.	150,000	0°
530 microns	170,000	—10°
17 microns	250,000	—70°
.5 microns	315,000	—110°
.137 microns	350,000	—130°

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Use our facilities to evaluate product operation under all environmental conditions. Get automatic alternating cycles of contrasting conditions...remote control of product operation by mechanical, electrical or hydraulic means... and a wide range of supply voltages and frequencies. Simulate high-low temperatures, humidity, altitude, explosion, immersion, salt spray, sand and dust, rain, fungus, vibration, shock, acceleration, etc. Test to military, government and commercial specifications.

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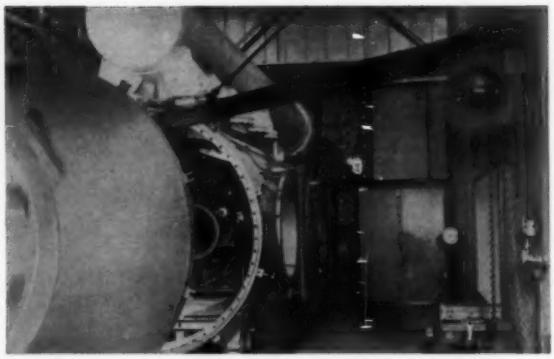
Commercial Environmental Labs...

In the complex, modern environment, old fashioned use testing is too slow, too imprecise, too expensive and often too dangerous. Commercial environmental labs provide invaluable supplemental facilities, specialized knowledge and experience and, most important, impartial testimony.



ALTITUDE . . . for an engine or a man . . . is standard in any environmental lab, but commercial labs frequently offer special facilities too costly for the average plant. Aerotest Laboratories, Inc.'s 70,000-foot chamber (above), 8½ feet in diameter and 20-feet long, is for evaluating steady state airbreathing engines and may be converted to a stand for 10,000-lb. class rockets. York Research Corp., Stamford, Conn., creates 200,000-foot altitudes in the walk-in chamber (below) being used to test space suit.

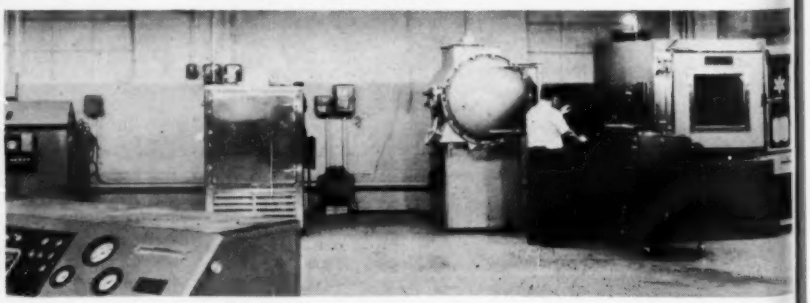
TIME WAS, IF YOU WANTED TO KNOW how good something was, you tried it. For modern requirements, however, use testing is too slow, too costly and very often highly impractical.

To get their answer, producers of an endless array of military and consumer items turn to commercial test

EXPERIENCE obtained from many assignments for many clients is a strong selling point for commercial environmental test labs. In subjecting crystal case relays to vibration (above), U. S. Testing pre-wires relays to a special connector which is plugged into an adapter box. This minimizes opportunities for error in measuring the wrong pair of contacts or mistakenly applying voltage to an improper position.

SPECIAL set-ups for special need is a commercial lab's specialty. At New York Testing Laboratories, Inc., New York, Gerald Horvitz watches a wind infiltration test of a monumental window for high structures.

VERSATILITY is a commercial test lab standard, especially in environmental work. A sampling of Belock Instrument Corp.'s equipment (below) in College Point, N. Y., shows a Genisco G-force accelerator control, an Industrial Filter salt spray chamber at the left rear, and rain and sunshine, explosion and strat chambers by Tenney Engineering.



...Testing All for Big and Small

laboratories. Their reasons vary. Chief ones are:

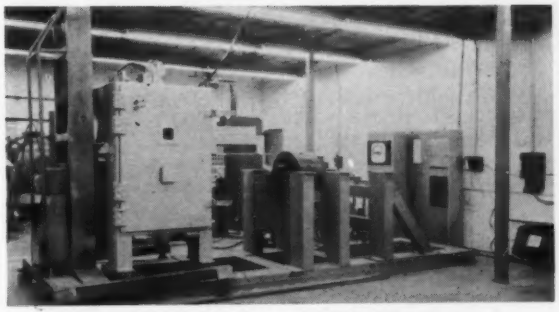
They can't afford their own test set up.
They can't handle the work load.
They haven't any experience along certain lines.
They want an impartial judgment.

Specialists, One and All

Environmentally speaking, independent commercial labs fall into three categories: those specializing in environmental simulation such as temperature, altitude, humidity, shock and vibration, acceleration and rain and sunshine and other climatic phenomena, those that do other kinds of testing under environmental conditions and those that supply unique skills in a particular field.

The last category especially has grown in recent years. Often such laboratory service is provided by manufacturers of special equipment.

Some of these labs have been around a long time. One tested the engine in which Lindbergh soloed across the Atlantic. Others are fledgling in years, but have a battery

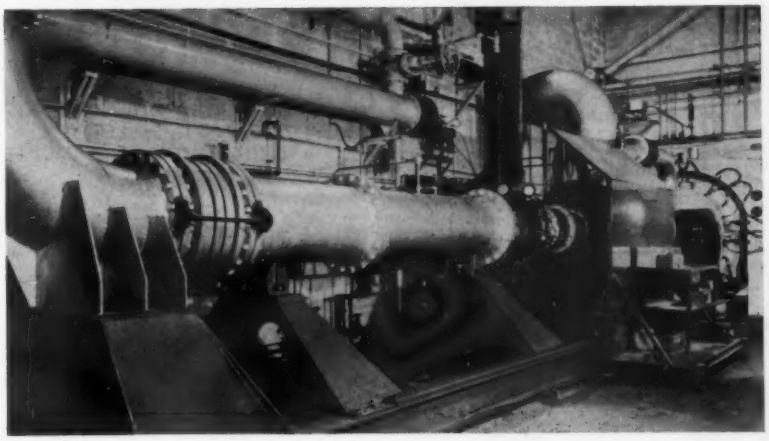


UP-TO-DATE equipment is assured at commercial labs, which amortize their investment over many tests for many clients. The Itemco altitude chamber and test stand (above) for vibration testing is featured by Itemlab, Inc., Port Washington, N. Y. It ranges up to 200,000 feet at −120° to +600°F. The calibration standards laboratory (below) at U. S. Testing Co., Inc., Hoboken, N. J., reflects the greater burden placed on commercial labs to establish a traceability to the National Bureau of Standards. This room is accessible to only four persons.

HANDSOME facade of York Research's administrative offices in Stamford typifies the stature achieved by commercial environmental test labs such as Stollardyne, Lambert Engineering, General Testing and Associated Testing on both coasts and across the continent.

EXTENSIVE facilities offered by commercial labs are illustrated by the test capsule (below) mounted in one of four cells at Aerotest's unusual turbine laboratory at Deer Park, N. Y. Direct fired preheater duplicates turbine discharge temperatures, sea level, steady state conditions. Downstream flame viewing and closed loop TV may be included, as well as altitude equipment. Aerotest's new Advanced Propulsion division does testing for the aircraft, missiles, industrial and automotive fields.

MANY business and consumer items find their way into commercial laboratory environmental test facilities. At New York Testing, telephone switchboards experience cycled temperature and humidity conditions in a walk-in chamber.



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of equipment and a warehouse of knowledge complex beyond the imagination of pioneer days.

Their service is nationwide, from Acton Laboratories in Massachusetts to Stellardyne Laboratories on the West coast. Some, like General Testing Laboratories in New Jersey, once had ties with equipment manufacturers and have since gone independent.

Equipment Is Expensive

In the environmental field perhaps more than in others, costs of equipment are responsible for the reliance on commercial laboratories. You can hardly compare the price of even a simple temperature chamber with that of a test tube!

Most companies can't afford to tie up capital by setting up and maintaining labs for occasional, sporadic test needs. Investment in a very modest lab has been estimated to run to $50,000 for equipment and twice that a year for staff and maintenance. One commercial lab reports it used nearly $50,000 worth of equipment for a test it charged the customer only $200.

Some manufacturers—Barry Controls, Inc., for instance—maintain test laboratories with the most modern equipment not only to prove and improve their products, but to solve customers' problems.

Some laboratories specialize more or less in certain fields. The Belock Instrument Corp. environmental laboratory, for example, performs military shock and vibration tests for light and medium weight equipment on the same table. But it also has a wide range of other environmental capabilities.

More Than A Chamber

The time has long past when a lab was content to just certify a product to military standards. Stellardyne Laboratories, deeply involved in space technology, has even coined a word, "comvironments," to describe its combined

(*Continued on Page 34*)

NEW ALI EXPANDED FACILITIES FOR ENVIRONMENTAL TESTING

ALI has complete testing facilities for:
HIGH & LOW TEMPERATURE, HUMIDITY, ALTITUDE, MILDEW-FUNGUS, SALT FOG & SPRAY, SAND & DUST, EXPLOSION, SUN & RAIN, VIBRATION - HIGH & LOW FREQUENCY, SHOCK, ACCELERATION, LIFE TESTS, RADIO INTERFERENCE TESTING.

ACTON LABORATORIES, INC. offers an environmental testing service, meeting both commercial and military specifications, to companies: (1) requiring independent certification of tests, (2) not in a position to justify the purchase of expensive environmental equipment, (3) whose own environmental facilities are in use on other projects, (4) who recognize the sales value in selling a competitive product that has been approved by an independent testing laboratory. Our facilities, engineers, technicians, and scientists are available to conduct the entire tests; or you may use our facilities and provide your own personnel to conduct the performance tests.

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NEW PRODUCTS

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by **General Acoustics Corp.** permit building any size test chambers for keeping noise, heat, cold or dust in or out. Panels are 28" wide and 8 or 10 feet long and contain special core materials for enclosing all types of environmental testing. Typical chamber is constructed of panels incorporating highly absorbent inside faces and special laminar core materials to prevent noise seepage. Panels can be easily assembled or taken down for future expansion, modification, or storage. In addition to blocking vibration, heat, cold, high intensity noise, radio and audio frequencies, the structures can be used for dust free assembly or observation rooms, mechanical equipment and engine test cells.

For More Information Circle EQ RSC #21

• • •

BOX TYPE FURNACE

with automatic electronic controller by **Blue M Electric Co.** with temperature up to 2,000° F. handles all types of heat-treating problems. known as **Stabil-Glow,** the line features Quick-Heat, a high wattage for rapid temperature rise, and then a power-saver reduction to low wattage operation. When set temperature is reached, wattage is automatically reduced to stabilize oven temperature, lower current costs, and eliminate overshoot and undershoot. Controller has thermocouple-relay indication system, double break contacts and solenoid type power contactors. Insulation is 4½" firebrick plus 1½" therm-o-block on all six sides.

For More Information Circle EQ RSC #22

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Complete functional and environmental testing of aircraft, missile and spacecraft equipment.

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Design and manufacture of special-purpose airborne and ground support equipment.

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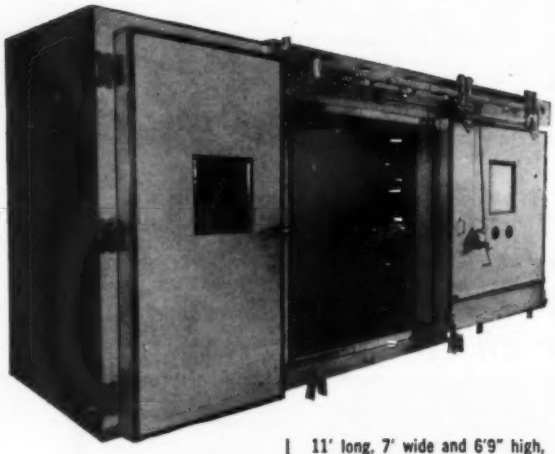
today's testing... tomorrow's product...



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Commercial Environmental Labs

(*Continued from Page 32*)

environments testing capacity.

"Environmental testing has become a science rather than a casual series of tests," observes Bernard Novack, vice president of Associated Testing Laboratories.

The modern environmental testing laboratory . . . must be a versatile engineering company which can perform tests as well as correctly operate all types of electronic, pneumatic and hydraulic equipment."

"In the field of component testing," says U.S. Testing's Richard F. Hahn, of the engineering department, "there has been an increasing demand for greater quantities of units to be environmentally tested and an increased need for reliability information. Laboratories must gear themselves to the demands for larger samples and more accurate information at moderate cost."

New York Testing Laboratories, Inc., which put the o.k. on Lindbergh's engine and has been in business over 40 years, has kept pace with the vast changes since the days when simple strength tests were enough.

Gerald Horvitz, its president, recalls vibration tests in 1942 of 5 to 55 cycles, of temperature tests from —10° or —20° F. to +105° F., of shock tests of a few foot-pounds. Now his tests run 2-4,000 cycles, —300° to over 1,000° F. and several hundred foot pounds. And the far higher ranges are ahead, with the sky, literally, the limit.

Market Research to Testing

Another big testing service, York Research Corp., started out two decades ago as market research specialists. It finally bought its own laboratory for product testing and went on from that to build an ultra-modern facility covering both military and non-military testing. Radio interference, acoustics, instrument calibration, and electrical, electronic, electro-mechanical and mechanical product development are some of its capabilities.

Lambert Engineering Company, strategically located as its points out "at the crossroads of the nation" in St. Louis, is a research and testing lab. It tests products to all governmental and industrial specifications as well as performing all types of environmental tests.

Aerotest Laboratories, Inc., provides an example of the service a test lab can give. Aerotest put nearly 2,000 electrical motors through their paces and reported 82% of them failed. Failures fell into three groups; moisture, shock and vibration, and temperature extremes. The lab told the manufacturer to redesign the sealing and provide for moisture drainage, and the majority of the motors passed after varying amounts of redesign. Aerotest then followed up with a study pointing to more careful selection of components and early spot testing before final assembly.

THERMOSEAL

. . . viewing glass units for environmental chambers. Tolerates —100° to +350° F differential. Prompt deliveries.

. . . *tempered glass units and tempered glass now available for rapid delivery.*

We also offer engineering service.

THERMOSEAL GLASS CORPORATION

P.O. Box 342 • Camden, N. J.

Twelve Missimers Chambers in Convair's huge laboratory include thermal shock, high and low temperature testing and humidity cycling.

Convair / Pomona Chooses Missimers

for "control accuracy, repeatability and ease of operation"

Reliability specifications of purchased electronic parts are determined through an unusually comprehensive program at Convair/Pomona, Convair Division of General Dynamics Corporation.

Called the "Quality Assurance Environmental Test" program, it was established primarily to make certain that environmental conditions specified could be met through successive lot deliveries.

Within a modern lab, twelve Missimers Chambers provide thermal shock, high and low temperature cycling and programmed humidity tests. These quality Missimers Chambers must meet particularly tough specifications of control accuracy, repeatability and ease of operation in order to make such a continuous program practical.

A complete line of Missimers Chambers is available for temperature, humidity, explosion, sand and dust and altitude testing in sizes and capacities to suit your requirements. Call or write for information.

MISSIMERS INCORPORATED
Since 1932
3737 San Fernando Road
Glendale, California • CHapman 5-8471

E. W. A.

(Environmental Want Ads)

Rates: $5 (minimum) for three lines, $2 per line additional. "Situation Wanted" ads free (except for reply box number) to those who can reasonably expect to find employment in the environmental industry, but prescribed form must be followed. First three lines free to those who write own "Situation Wanted" ads. Reply code number $2 extra but no charge for handling replies. Payment in full with copy, except from recognized agencies.
Deadline for July, 1960, issue is June 10, 1960. Send order, copy, payment and all inquiries to Environmental Want Ads. Environmental Quarterly, 252-46 Leeds Rd., Little Neck 62, N. Y.
For free "Situation Wanted" ad give only following information in this order: Job title (two permitted), age, (if desired), degrees, recent experience, salary desired, where you prefer to work and name and address. (Last two will be withheld if reply code is used.)

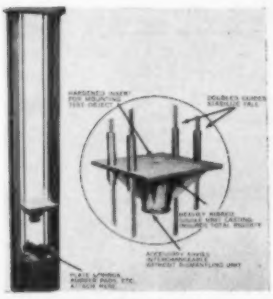
SITUATIONS WANTED

ENVMTL LAB SUPVR, BS/ME, facilities & instrmntn supvr, sal open, EQ #20.

MGR, DIR, BS/ME, dir envmtl testg and evaltn, sal open, EQ #21.

NEW PRODUCTS

IMPACT SHOCK TESTER



Model F-3003-B, by Jan Hardware Mfg. Co. Inc., is designed for testing components up to 12 lbs. or 6 cu. in. Impact loadings from 15 to 3,000 Gs can be handled on totally rigid, precision-machined, single-unit carriage. Supplied in cast aluminum, but magnesium casting is available, with interchangeable anvils of aluminum or hardened steel. Extra-long carriage guide rods stabilize the fall. The unit stands 67" high, 12" wide and is 8½" deep.

For More Information Circle EQ RSC #1

NEW PRODUCTS...

A "Reader Service Card" requiring no postage is bound into this issue for the convenience of those desiring additional information on new products, new literature (Page 22) and other announcements. It is keyed in the text as "EQ RSC."

WIRE AND INSULATION TEST CHAMBERS

in a new line by **Cincinnati Sub Zero Products** have an ingenious method of bending wire while it is being subjected to extremes of cold. One-piece cabinet, constructed of 16-gauge steel with a 10-gauge extra-strength steel base, measures 84" x 20" x 42" deep outside. The test chamber, of 14-gauge galvanized steel, is 12" x 12" x 72". For "cold bend" test to mili specs, a mandrel can be installed in the upper part of the chamber. A wire under test is attached to the mandrel, and a specified weight is attached to the free end of the wire, which is wound on the mandrel by an outside control without disturbing the test temperature. After winding, the sample is examined for surface cracking and other flaws.

For More Information Circle EQ RSC #2

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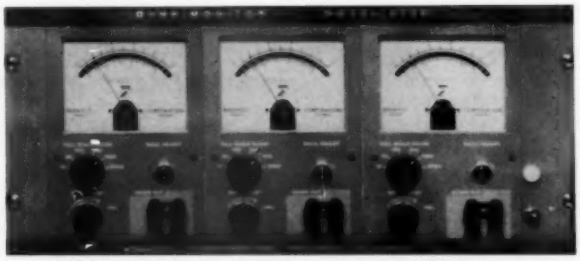
'DYNA-MONITOR' VIBRATION AMPLIFIER AND MONITOR



Model 2702, by Endevco Corporation, monitors and amplifies vibration, shock, pressure and force signals. Three channels handle the output of piezoelectric transducers and other high impedance devices, with each amplifier section containing its own voltage amplifier, power amplifier and meter. High frequency galvanometers can be driven from the power output. Features include: driven shield cathode follower input, precision VTVM readout or direct reading in gs or other parameters, high gain and high frequency galvanometer output. Frequency response claimed is ±5% in the following ranges: 3 cps to 10 kc with 1,000 uufd source capacitance or greater; 5 cps to 10 kc with 500 to 1,000 uufd; and 10 cps to 4 kc with 200 to 500 uufd. Prices range from $950 for the single channel model to $1,750 for three channels.

For More Information Circle EQ RSC #3

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INFRARED PHOTOELECTRIC SCANNER

Type SA-IR, by Farmer Electric Products Co., Inc., combines an energy source and detector in a unit only 2¼" long and 1⅛" in diameter. Responds to metallic and non-metallic objects and will count or control operations at distances up to two inches. The infrared source operates on 5 volts d.c., and has a 60,000-hour rated life.

For More Information Circle EQ RSC #4

CARBON DIOXIDE WELDING GUN

Model AH60-B, by Air Reduction Sales Company is air-cooled and rated at 600 amps using CO_2 as a shielding gas for its arc. It can accommodate hard welding wires ranging from .035" through 3/32" feed from conventional Airco wire feeders. Gun has a lever type trigger and a gooseneck nozzle assembly for hard-to-reach areas.

For More Information Circle EQ RSC #5

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SMALL COMPONENTS TEST CHAMBER

by Standard Cabinet Company, Inc., is designed for environmental testing by the manufacturer of small components. Compact, versatile and dependable, it provides 2.6 cu. ft. work space, has low operating costs and is priced for limited budgets. Temperatures from —120°F. to 200°, 300° or 500°F. Available to include humidity and/or altitude. Optional equipment includes windows, lights, terminals, recording or programming controls and casters for mobility.

For More Information Circle EQ RSC #6

CONRAD Inc.

TEMP-RAC 19

HIGH-LOW TEMPERATURE TESTING WHEN & WHERE YOU WANT IT!

Testing small assemblies and components to military and government specifications is simple and convenient with Conrad's new Temp-Rac 19. Move it anywhere in your laboratory, any place on your production line. Temp-Rac 19 has a range of —90° to +300°F., 16" x 16" x 16" I.D. test area, and it's air cooled, requiring only electricity for operation. One or more of these compact chambers can give your facilities the flexibility that assures more efficient testing and production. Ask your Conrad representative to show you. Write today.

- 16"x16"x16" I.D., clear of coil and circulator.
- Occupies only 4 sq. ft. floor space — easy to move on heavy duty swivel casters supplied with chamber.
- Light recessed into chamber ceiling.
- Safety mesh for fan.
- Patented Conrad Cascade Refrigeration System.
- 220 volt, single phase, 60 cycle, 3-wire service.
- Optional features include view window in door, access ports, removable door with shelf assembly, terminal pads.

CONRAD Inc.

HOLLAND
MICHIGAN

Introduced only a few months ago, the Conrad Temp-Rac 19 has won quick acceptance because of its wide application in production and testing. Conrad suggests placing orders early to assure delivery from stock.

Subsidiary,
Crampton Mfg. Co.
Grand Rapids,
Michigan

NEW PRODUCTS

ALTITUDE-TEMPERATURE-HUMIDITY SIMULATION CHAMBER

by **Murphy & Miller, Inc.,** offers king-size testing in 6′ x 6′ x 6′ welded stainless steel interior. Fully automatic door glides up and down on a track and is said to seal tight enough to withstand perfect vacuum pressures. Operating range: —120° F. to +300° F., humidity cycle from 20% to 95% over temp. range of +35° F. to +185° F., altitude to 100,000 ft. F13/F22 cascade refrigeration system can be side or rear mounted. Instrumentation is by electronic recorder controllers with automatic percentage capacity control. Six-inch diameter ports permit insertion of vibration thrust rods. Has 100 single-pin electrical terminals mounted on a removable plate.

For More Information Circle EQ RSC #7

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METAL FOIL DECAL

by **Wrisley Engineering, Inc.,** provides a simple, cheap method of spot-checking vibration measuring systems during tests. With only the naked eye and a simple light source, the user is said to obtain accuracy of ±5% with the **Vibracal.** An optical indication of vibratory motion of .085 inches double amplitude is said to be provided when the decal is fastened to shake tables, fixtures or test specimens near the vibration pick-up. Several optical patterns are available. Kit of five decals with instructions is $1.75.

For More Information Circle EQ RSC #8

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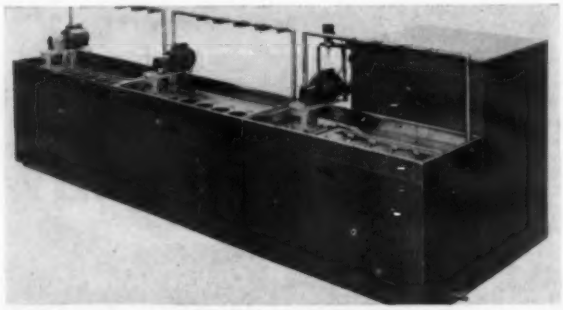
THREE-ZONE LIQUID CALIBRATION BATHS, +150°C. to —85° C.



by **Harris Refrigeration Company,** has three separate agitated chambers for precision calibration on a mass production basis. One provides 50° C. to 150° C. with a capacity of 6,000 BTU's per hour; one, 50° C. to 20° C., 1,000 BTU's; and one, —20° C. to —85°C., 6,000 BTU's. Recovery time is fast—10 minutes with 1,000 BTU thermal load after loading to capacity. Temperature variation in each bath is less than 1°C. Point control (repeatability, speed of response and on-off differential) ±.1°C. Unit pictured has 5 cu. ft. each chamber. Available in all sizes and requirements down to bench types of 4" diameter x 4" deep.

For More Information Circle EQ RSC #9

FLIGHT SIMULATION TABLE

Model 17A, by Micro Gee Products, Inc., for flight testing on the ground of complete missile or space stabilization and control systems. The two axes have natural frequency in excess of 15 cycles/sec, with adjustable damping and individual thresholds of less than .005 degrees. The table has extended angular travel and can handle a 25-lb. load. The two-degrees-of-freedom table can be used for angularly displacing gyros and accelerometers, in pitch and roll, statically or dynamically. The smooth-operating driven pendulum mechanisms permit oscillation tests for threshold characteristics. Table will follow signals from an analog computer, low frequency function generator, tape recorder or digital-to-analog converter.

For More Information Circle EQ RSC #10

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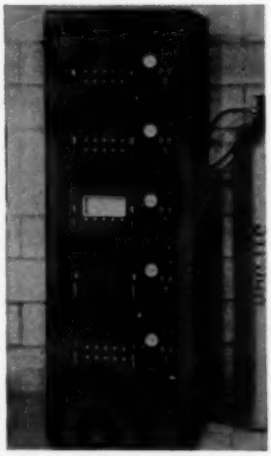
PORTABLE TEMPERATURE CHAMBERS



Series 1060, by Delta Design, Inc., are said to have an accuracy within ±2° F. over a range of —100° F. to +500° F. It uses a meter-relay with a copper-constantin thermocouple. The series includes a rack mounted and two bench models, all with capacities of 10" x 7" x 7", and a wide-drawer model of 16"x7"x7" test volume. Three of the models use liquid CO_2; the fourth, dry ice. Employing 650-watt heating elements, the units have centrifugal blowers for temperature uniformity and plug right into the wall. Liquid CO_2 chambers can be programmed by an auxiliary timer to alternate between high and low temperatures. The 1060 Series and Delta's **Series 6545** are available in racks. Pictured are a group of the 6545 series in a standard 19-inch rack. Up to five chambers can be mounted, providing five pre-selected environments, from —100° F. to +500° F. Test drawers are interchangeable, permitting quick thermal shocking by moving a drawer from one extreme to an opposite in seconds. Floor requirement: four square feet.

For More Information Circle EQ RSC #11

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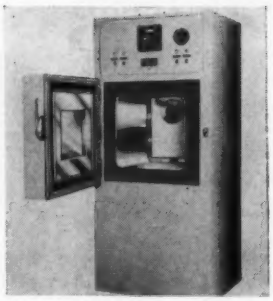
DATAFLASH

is **Consolidated Electrodynamics Corp.'s** new technique for providing a usable record of an oscillograph in less than one second. Passing the oscillogram over a heated platen as the latent image is brought up by a high-energy light stops formation of background fog and speeds the latensification. Oscillograms with good contrast are produced without chemicals and 60 times faster than using print out papers.

For More Information Circle EQ RSC #12

'ADD-ON' TEMPERATURE TEST CABINET

by **Hudson Bay Co.**, has special provision for adding altitude and humidity as required. Designed for laboratories with expanding environmental test requirements, it is called **Com-pac Cab**, has 19" x 19" x 19" work chamber and an adjustable temperature range from 300° F. to —120° F. Construction features include a galvanealed all-steel electrically-welded cabinet with a frostproof multipane door and a 40-watt interior light. Overall dimensions are 74" x 32" x 32". The unit has a sealed-in oil supply, thermal overload protector and



operates from a 230-volt 60-cycle single phase motor. Can be ordered as a horizontal or vertical floor unit, or for bench use.

For More Information Circle EQ RSC #13

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ALTITUDE TRANSDUCER AND RECORDER-CONTROLLER

by **The Bristol Company** gives linear readings over the entire scale of simulated altitude test conditions. The Sostman altitude transducer converts pressure to an electrical signal in the Bristol dynamaster instrument. Standard ranges are from 0-50,000 ft. to 0-150,000 ft.

For More Information Circle EQ RSC #14

ACCELEROMETER CALIBRATOR

Model 4290, by **Bruel & Kjaer Instruments, Inc.**, is designed to vibrate accelerometers or other small vibration pickups at a constant level from 50 to 30,000 cps. Will automatically measure and plot accelerometer response calibration from 200 to 20,000 cps and indicate its mounted resonance up to 50,000 cps.

For More Information Circle EQ RSC #15

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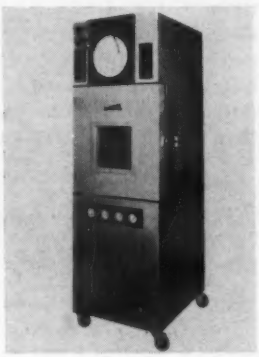
MOBILE ENVIRONMENTAL CHAMBER

Model AF —1.5 —125 +350 by **Webber Manufacturing Co., Inc.**, features fast temperature change and good accuracy. Range is from —125° F. to +350° F. Special entrance ports at the door eliminate feed-through ports and terminal panels for instrument cables. Temperature can be dropped from +350° F. to —100° F. in 50 minutes and reversed back up again in 30 minutes with an accuracy of ±2°. Other features are a 24-hour recording chart, interior lighting, multi-pane thermal glass door assembly, hermetically sealed heating elements, special safety controls, stainless steel interior and 16-gauge



baked steel exterior. Interior dimensions are 14" x 14" x 14", and the unit requires only 26" x 32" floor space. Mounted on casters. Power needs are 220v, 1 ph, 60 cycle; or 220 or 440v, 3 ph.

For More Information Circle EQ RSC #16

You can DEPEND on -- Standard

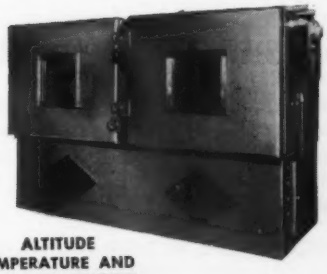
TEST CABINETS

FOR ACCURATE DEPENDABLE

ENVIRONMENTAL TESTS

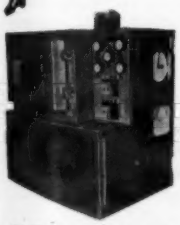
HIGH and LOW TEMPERATURES, ALTITUDE, HUMIDITY, FUNGUS, SAND and DUST, SALT SPRAY, RAIN and SUNSHINE, EXPLOSION and SPECIAL APPLICATIONS.

Every Standard test cabinet is designed for reliable and accurate testing, along with years of care-free durable operation. Whatever the simulated condition is desired to test your product accurately . . . correctly, there is a Standard cabinet to do the job. All guaranteed to give high level performance — the result of a decade of engineering skill and experience in designing and fabricating test equipment. Why not look into the many outstanding features offered by Standard today . . . send for our illustrated Catalog No. 59.



ALTITUDE TEMPERATURE AND HUMIDITY CABINET

VIBRATION TEST-LIQUID CO₂-MECH. REFR. OPTIONAL



TEMPERATURE CABINET (OPTIONAL HUMIDITY)

self-contained units to meet every condition

WALK-IN EQUIPMENT FABRICATED TO ORDER

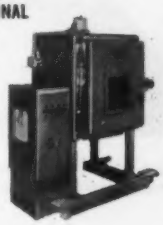
Standard CABINET COMPANY

MEMBER OF ENVIRONMENTAL EQUIPMENT INSTITUTE

50 WASHINGTON AVE.

CARLSTADT, N. J.

DESIGNERS-MANUFACTURERS OF TEST EQUIPMENT



ENVIRONMENTS IN USE...

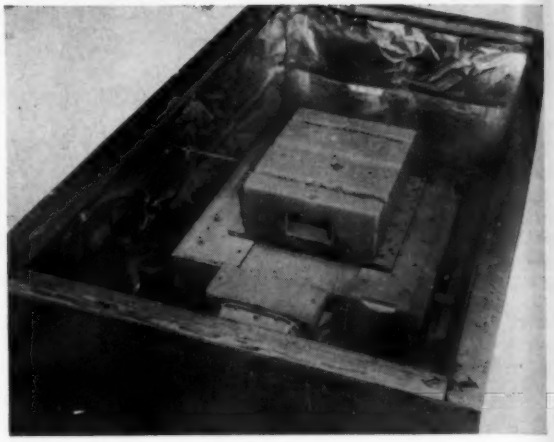
Inuring Reaction Vibrators to Extreme Temps

The Problem: L.A.B. Corporation, Skaneateles, N. Y., was called on to deliver several reaction vibration machines (Model RVH-36-500) to an aircraft manufacturer who wanted them for combined vibration and temperature tests in a temperature range of −80° to +160° F. The vibration tables of the machines—with test load capacities of 500 pounds, operating frequencies from 5 to 60 cycles per second and maximum displacements of 1/16-inch—would be inside an environmental chamber, the power units outside. In the chamber wall would be dual flexible coupling drive shafts and jack shafts.

THE SOLUTION: To protect the equipment from condensation and rust, the exposed steel surfaces of the vibration tables were painted with a rust inhibiting undercoat and all unpainted parts and fasteners were made of stainless steel. The vibration table weldments were fabricated of nickel bearing U. S. Steel type T1 alloy because of its greater strength at low temperatures. Special nickel bearing alloy welding rods were also used in order to insure strong welds that would not fatigue and crack under sustained periods of vibration.

Lubrication was another problem. The ball bearings which carry the vibration generator eccentric weights and shafts are normally lubricated with a high temperature grease, as rotation of the bearings at speeds up to 6,000 RPM often generate temperatures above 160° F. under normal operating conditions. However, this high temperature grease becomes stiff at extremely low temperatures. After several low temperature tests, it was discovered that a silicone grease, Dow Corning Type DC33 retains its viscosity at low temperatures better than any other type of lubrication. The DC33 lubricant was therefore specified, and a synthetic aircraft turbine oil was used to lubricate gears in the vibration generators.

To prove out the modifications and evaluate the effects of low temperatures on lubricants, L.A.B. designed and built a cold chamber. Constructed of 1/2-inch plywood walls and insulated with 4" of aluminum-backed fiber glass batting on the inside, the chamber had a test volume of approximately 130 cubic feet.



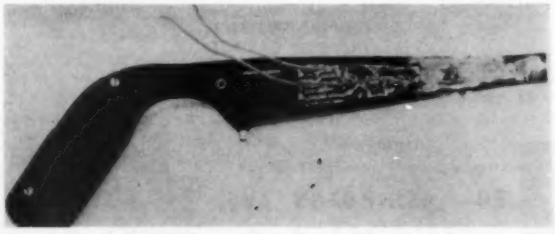
Co'd chamber designed by L.A.B. Corporation, with reaction vibration machine under test. The temperature is −80°F.

The vibration machine was chilled with liquid carbon dioxide introduced into the chamber through a thermostatically controlled valve system. An extremely simple system, it consists of a thermostat and a relay to operate a pneumatic regulator which introduces the CO_2 automatically to compensate for temperature changes. The pull down time to chill the 2,000 pound mass of the reaction vibrator from +40° to −80° F., was approximately two hours.

Although the plywood cold chamber was constructed of conventional building materials, insulating properties were excellent and the chamber proved effective and economical.

Sensitive Hearing Aid Has a Salty Time

The Problem: Telex, Inc., manufacturer of miniature hearing aids found the perspiration of wearers contaminated tiny electrical parts. Moisture and salt accumulation caused switches to fail or develop excessive noise.



Hearing aid whose new rotary switch survived weeks of salt brine immersion tests.

THE SOLUTION: Howard L. Daniels, former Remington Rand Univac engineering director and now special consultant to Telex's research and development staff, inaugurated an environmental test program as rigorous as those used to qualify electronic components of missiles or aircraft for military use.

The rigid tests covered temperature extremes, shock, vibration, dust and salt brine immersion. To withstand these, a new switch had to be designed with rotary, self-wiping action and heavy contact pressure. A platinum-palladium-gold alloy was employed for the contacts.

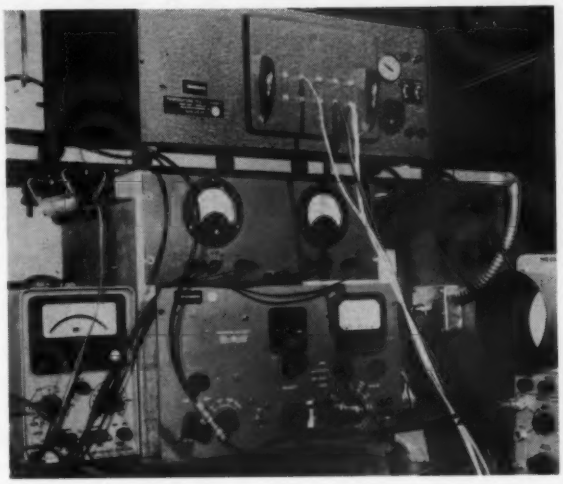
The result was a rotary switch that continued to operate after weeks of salt brine immersion and despite encrusted salt deposits. Standard sliding-action switches are said to have failed almost immediately when exposed to the same environmental tests.

Double Duty Helps Amortize Investment in Chamber

The Need: At Sandia Corp.'s big environmental test laboratory in Albuquerque, the 20-man Telemetering Systems division sought a method of speeding the evaluation of miniaturized electronic components and airborne telemetering equipment under simulated operating conditions.

THE SOLUTION: Sandia purchased half a dozen portable temperature chambers from Delta Design, Inc., San Diego, Calif. The units each measure 10" x 24" x 14" and have a test volume of 800 cubic inches. They can be carried from test station to test station as needed, and they can be swiftly cooled with solid or liquid CO_2 to cryogenic levels.

Subsequently Sandia found another use for the chambers, giving it even more efficient usage. The unexpected advantage was in the chambers' ability to reach the $-100°$ to $+500°$ F. range in a hurry, and the fact that they can be mounted easily on work tables. So the chambers are also being used to cure resins for small component encapsulating, a case of making the investment in specialized equipment pay off.

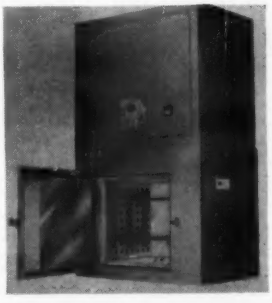


Delta Design's portable temperature chambers, bought for environmental testing, which Sandia Corp. put to additional use for curing resins.

NEW PRODUCTS

SATURABLE POWER REACTOR CONTROL

for **Blue M Electric Co.'s Power-O-Matic 60** mechanical convection ovens are said to have no contacts to arc or burn and no photo cells, tubes or auxiliary elements. Instead the power reactor in combination with a stainless steel hydraulic bellows and a variable gap inductor coil automatically varies the voltage to the resistive load. Full power is used only during the initial heat period; thereafter the resistive load receives only enough power input to replace temperature losses. The control system is stepless, switchless and infinitely proportional, and permits constant, straight-line and repetitive temperature through the entire oven range of 350° F. to 650° F. A foolproof safety device is claimed to prevent overheating.



For More Information Circle EQ RSC #17

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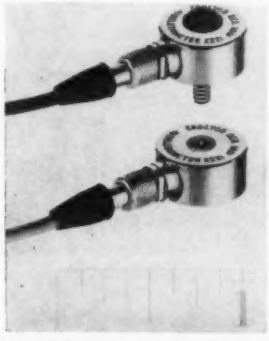
RING-SHAPE ACCELEROMETER

Model 2221, by Endevco Corporation, is only .6 inches in diameter, .43 inches high and weighs but 11 grams. It has a central mounting hole, 6-32 x 5/8, allowing connector alignment, and standard mounting hardware for ground isolation. Frequency response from 2 cps to 4,000 cps is within $\pm 5\%$ with 1,000 megohm output, less than 5% cross-axis sensitivity. Temperature range $-40°$ F. to $+230°$ F. with $\pm 10\%$ sensitivity change. The device has a high first resonant frequency of 25 kc, sensitivity of 5 pk-mv/pk-g (charge sensitivity: 1.4 micromicrocoulombs plus dynamic range of 2,000 gs.



For More Information Circle EQ RSC #18

INTEGRATED CONTROL FOR LOW-HIGH TEMPERATURE CHAMBERS

using liquid CO_2 for cooling by **Development Engineering Company, Inc.** is designed for both new and converted equipment. **Model KT** shown contains all necessary equipment and wiring for CO_2 cooling and for heating by electric control. In gray hammertone case, 6" x 10" x 3½" deep, the control takes only 10 minutes to install. It has the **DEVELCO** pulse system to maintain close tolerances of temperature as well as lowering CO_2 consumption; plug-in connections for temperature controller, fan motor and the heating circuit; interchangeable CO_2 nozzles and provision for future manifolding of CO_2 tanks. Available without a thermostat or with various types of controls, the base unit sells for $175.

For More Information Circle EQ RSC #19

* * *

HIGH VACUUM FURNACE

Model 58-HD, by Marshall Products Co. permits hardness tests at temperatures up to 3,000° F. Heating element is a rolled sheet of molybdenum 3" I.D. by 12¾" long. Loading mechanism is entirely within the vacuum system to prevent external error; indentor movement allows hardness impressions on three different reference circles, and the anvil and stage can be rotated 360° for maximum impressions without breaking the vacuum.

For More Information Circle EQ RSC #20

ENVIRONMENTAL BUSINESS...

ATL Opens Major Test Lab in South

One of the South's first major environmental test facilities, Associated Testing Laboratories' "space reliability center" at Orlando, Fla., went into early operation in February.

The 10,000-square-foot plant, with unusually high, 25-foot ceilings, is to be among the most completely equipped of its kind in the Southeast, according to ATL's president, William Tonkowich.

Tonkowich called the center, with its environmental, electronic, pneumatic and hydraulic equipment, an advanced facility to serve "the new age of space science and missile development."

Martin-Orlando Contract

The facility is under contract to The Martin Company to perform reliability and environmental tests on missile parts from Martin's Orlando plant. In addition, it will serve other prime and subcontracting firms engaged in space and missile work in the Southeast and Cape Canaveral area.

The new plant, located at 1112 Solana Avenue, Winter Park, Orlando, will have a staff of more than 100 specialists, Tonkowich said.

Aerotest Completes Move to Deer Park

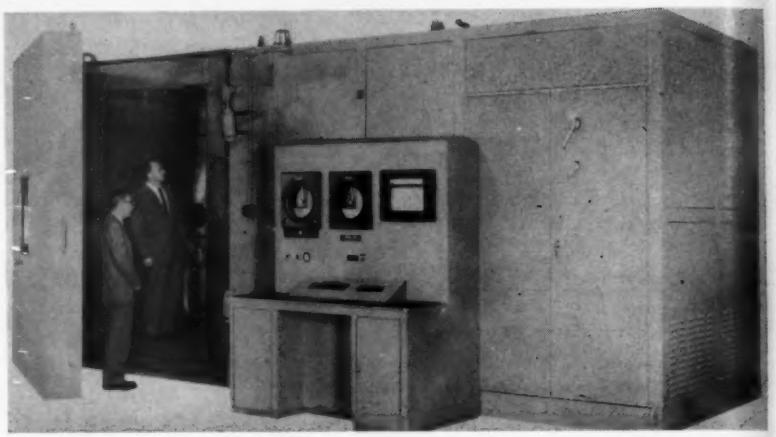
Aerotest Laboratories, Inc., has finished packing, moving and unpacking into its new multi-million dollar home at Deer Park, N. Y.

Aerotest, a leading Long Island independent test and research firm, took over the gas turbine lab built by Fairchild Engine & Airplane Corp. in 1955 on a 14-acre site beside Deer Park airport.

It will be the center of Aerotest's new advanced propulsion division, handling research on all types of engines, as well as the environmental testing and manufacturing of special-purpose equipment previously conducted at Aerotest's old home at College Point, N. Y.

Labline Sponsors $1,000 Award

Labline, Inc., Chicago laboratory equipment manufacturer and parent of the Hudson Bay Co., environmental equipment manufacturer, will sponsor an annual $1,000 award for outstanding contributions to chromatography and electraphoresis. Winner will be chosen by the American Chemical Society with the first award to be given next year.



Dr. Carl T. Ashby, president, and Charles F. Conrad, application engineering manager, of Conrad, Inc., inspect giant "flight test simulator" Conrad has delivered to Bulova's research laboratories.

One of a Pair from Conrad to Bulova

Two big environmental test chambers were recently delivered by Conrad, Inc., Holland, Mich., to the Woodside, Long Island, plant of Bulova Research and Development Laboratories, Inc., subsidiary of Bulova Watch Co. Inc.

Bulova R & D works on missile warhead components and other electronics and missile systems.

The larger of the chambers, described as a flight test simulator, is the size of a boxcar, weighs 22 tons and is one of only a few in existence capable of combining altitude and temperature stresses with a full range of vibration tests. Environmental temperature and pressure conditions of space flight, as well as vibrations encountered, can be exactly controlled, Conrad says, and recorded on a continuous strip chart. The chamber, which can simulate altitudes to 350,000 ft., has a 10" diameter accessory opening, several cable penetrations and many terminal feedthrough fittings.

The other chamber added to Bulova's million-dollar environmental facility has a 64-cubic foot capacity and will also simulate any temperature or humidity encountered on earth, or up to 66 miles overhead. Altitude equivalent of 100,000 feet can be reached at a 25,000-foot per minute climb rate. An unusual feature is strip chart recording over the full altitude pressure range. *(Circle EQ RSC F.)*

Want To Know Something?

The bill for all American research and development—government and private industry—is expected to hit $12 billion for this year. That's about two years sooner than the crystal ball boys had forecast.

Murphy & Miller Renames Environmental Division

Murphy & Miller, Inc., Chicago chamber manufacturer, has changed the name of its Environmental Products division to the Manufacturing division. Nick E. Miller, environmental products sales manager, has become sales manager of the firm's Contracting and Air Conditioning division, with R. W. Farrell, succeeding him.

At the same time, Paul H. Brandt, general manager of the Manufacturing division, announced the appointment of W. A. Tranbarger, formerly of Trop-Arctic and the Guardite Co., as his production manager. Hans Jacob continues as the division's chief engineer.

JOHN J. McDONALD and **LINDEN G. CRIDDLE** have been elected vice presidents of CONSOLIDATED SYSTEMS CORP., Monrovia, Calif. McDonald will continue as director of engineering, and Criddle as director of operations.

Ling-Altec Adds 3 to Staff

Three additions to the staff of Ling-Altec Electronics, Anaheim, Calif., have been announced. Cmdr. Allyn B. Ostroski, formerly air material officer of the Atlantic Fleet, has been appointed director of defense planning. Herbert D. Copeland, previously with Magnavox Research in Los Angeles, has become director of purchasing, and Edwin A. Andress has joined Ling Electronics division's sales staff.

400° above to 110° below in minutes*

TEST CHAMBER TEMPERATURE

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CO_2 is Best... For Test

The Pureco CO_2 *Blast Cold* process is a simple, efficient low cost method of refrigeration for low temperature test chambers. Direct injection of Pureco carbon dioxide liquid drops temperatures to required levels in a fraction of the time required by mechanical units. Cooling is produced by vaporizing a jet of liquified CO_2 directly into the chamber.

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Temperatures are automatically controllable within limits closer than government testing standards require. Pureco CO_2 *Blast Cold* starts immediately at maximum rate the instant valves cycle on—stops the instant CO_2 flow is cut off.

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No heavy investment required for equipment . . . installation is simple and space saving. Equipment is trouble-free. There is virtually no possibility of mechanical failure.

Direct or Indirect Cooling.

CO_2 liquid may be injected or DRY-ICE placed directly in a chamber—used to cool a circulating air stream or a non-freezing solution for indirect cooling.

Have a trial Blast Cold demonstration.

Pureco would like to demonstrate *Blast Cold* to you at *your* plant under your working conditions, with no obligation on your part. Pureco's Technical Sales Service will provide any assistance you need to help solve your low temperature testing problems.

**Actual Pureco Test*

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VIBRATION

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MISSILE SHOCK TESTING SAWTOOTH, SINE, SQUARE WAVE.
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Sales Representatives in all Leading Cities

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TEMPERATURE and ALTITUDE
CHAMBER and TEST STAND
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Components and assemblies can be vibrated in altitude chamber or free air, both horizontal or vertical, up or down.
Chamber Range: 0 to 200,000 ft. at −120°F. to +600°F.
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Environmental Business

Unholtz-Dickie, Others Appoint New Sales Reps

Unholtz-Dickie Corporation, Hamden, Conn., vibration test systems and instruments manufacturer, has appointed eight representatives for regions covering the whole country. They are: Space-Tronics Inc., Mineola, N. Y. (Long Island, metropolitan New York and northern New Jersey); R. P. Kennedy Co., Rochester, N. Y.; C. E. Snow, Philadelphia; W. A. Brown Associates, Indian River City, Fla.; S. Sterling Co., Detroit; Brooks Feeger Associates, Albuquerque; Remco Engineering Representative, Seattle; and The Kennematt Co., Van Nuys, Calif.

Associated Testing Laboratories, Caldwell, N. J., has appointed ARCO Engineering Co., Washington, as its government representative.

Wyle Manufacturing Corporation, El Segundo, Calif., has chosen the K. C. Bass Company to be its field engineering representative in eastern Los Angeles and surrounding metropolitan area.

Ling-Altec Sets Up Research Division Headed by Hilliard

Ling-Altec Electronics, Inc., Anaheim, Calif., has created a research division to conduct product planning and to supplement R & D activities of the company's 11 subsidiaries and divisions.

Hilliard

The new division, headed by John K. Hilliard, will also be available to the military and to industry for contract work in sonar, radar, environmental testing and acoustics, Cameron G. Pierce, president of Ling-Altec, said. *(Circle EQ RSC H.)*

Dr. Walter T. Fiala is the division's chief physicist.

ATL Officers Reelected; George Named a Director

William Tonkowich and Bernard Novack were reelected president and vice president, respectively, of Associated Testing Laboratories, Inc., Caldwell, N. J., by the board of directors. Albert F. Erdman, a director, was chosen secretary, and George E. George, president of George, O'Neill & Co., Inc., was elected a director. ATL maintains extensive specialized equipment for environmental testing at its Caldwell, N. J., plant, and manufactures a broad line of environmental test chambers and other equipment.

Bethlehem Foundry In Chamber Field

Bethlehem Foundry and Machine Company, Bethlehem, Pa., has organized an Environmental Engineering division to manufacture environmental test chambers, Albert A. Sickler, vice president and general manager, announced.

Mr. Sickler said the division will be managed by Bernard Friedman, formerly of International Radiant Corp. It will produce a line of "Dynatherm" test chambers for proving reliability of electronic components and weapons systems.

Test parameters of the new Bethlehem Foundry equipment will include very low and very high temperature and space atmosphere simulation in small portable and large drive-in type equipment. Hyper-environmental space chambers will incorporate the Beth-Tec molten salt thermal system to attain temperatures of more than 1,000° F. without pressure. The line will include humidity, explosion, sand and dust, fungus, salt fog, rain and sunshine and high pressure units. *(Circle EQ RSC I.)*

DR. THOMAS F. MALONE, director of research for The Travelers Insurance Companies, Hartford, has been elected president of THE AMERICAN METEOROLOGICAL SOCIETY for a two-year term.

Cameron

Johnson

CVC Opens Sales Offices

Consolidated Vacuum Corp., Rochester, N. Y., has established eastern and western regional sales and service offices in Philadelphia and Palo Alto, Calif. William C. Cameron is eastern manager, and Robert O. Johnson, western manager. Both men previously headed the district offices in their respective cities.

CEC, Bell & Howell Merge

The formal merger of Consolidated Electrodynamics Corporation into Bell & Howell Company has been completed, with the Pasadena electronics firm becoming a subsidiary of the Chicago photographic equipment manufacturer. CEC will continue to operate under its present name and management. Three CEC directors, including Philip S. Fogg, president and board chairman, were elected to B & H's board.

Optron Model 703 Tours Eastern U. S.

The Optron Corp. of Santa Barabra, Calif., is just completing a two-month series of demonstrations in plants from Chicago to Massachusetts of its newest vibration measuring instrument.

A kit consisting of the new daylight Optron Model 701 and a portable shake table is brought right into plants requesting it and put through its paces.

The 701, unlike older models which needed a dark room, can be used in ordinary industrial lighting. Its spot of light, focused through any of five interchangeable lenses on small targets fastened to the test object, can measure, for instance, flutter in a missile wing with a claimed accuracy of .001".

Optron said the considerable interest expressed by the environmental industry led it to schedule a full two months of demonstrations in Ohio, Pennsylvania, New Jersey, New York, Connecticut and Massachusetts.

* * *

LESLIE V. SPENCER has joined Alfred L. Lino Associates, Inc., St. Petersburg, Fla., ad agency. **PHILLIPS B. FRANKLIN** succeeded him in his former post of manager, public relations and advertising, ELECTRONIC COMMUNICATIONS, INC., St. Petersburg.

OBSOLESCENCE IS NOT ALWAYS OBVIOUS

MATERIALS TESTING HAS BEEN MOVING AHEAD

We at BEMCO have also been moving ahead with constant improvements in our products. The complete BEMCO line includes high temperature chambers for use with Universal test machines in determining stress-strain curves between 200°F and 1200°F. The work space within this chamber is 6" dia. by 10". In spite of the small outside diameter, the sides of this unit are maintained below 140°F while the inside is at 1200°F. This is accomplished by use of an air cooled reflector. The chamber is stored within the control panel. BEMCO also manufactures advance performance chambers for altitude, vacuum, temperature, humidity, sand and dust, salt spray, explosion, sunshine and rain. Many types are immediately available from stock.

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BEMCO INC.

11631 VANOWEN STREET NORTH HOLLYWOOD, CALIF.

Member of the E.E.I.

Since the input impedance of a cathode follower (Z) is basically a constant, the low frequency cut-off point can be established by equating.

$$x_c = Z \quad \text{or} \quad \frac{1}{2\pi fc} = Z.$$

Therefore the low frequencies cut-off point is

$$f = \frac{1}{2\pi Zc}$$

The circuitry associated with some of the newer types of crystal pick-ups is adequate to provide the low frequency response required. Certain makes of these accelerometers are now extremely useful for shock pulse measurement, since both the high and low frequency portions of the spectrum are faithfully reproduced. This type of crystal pick-up gives the best results for monitoring the steep terminating edges of some of the newer saw-tooth pulse specifications.

Shunting the Crystal Element

Another method sometimes used to improve the low frequency response of crystal accelerometers is to shunt the crystal element with an external capacitance. This reduces the (capacitive reactance and thereby lowers the

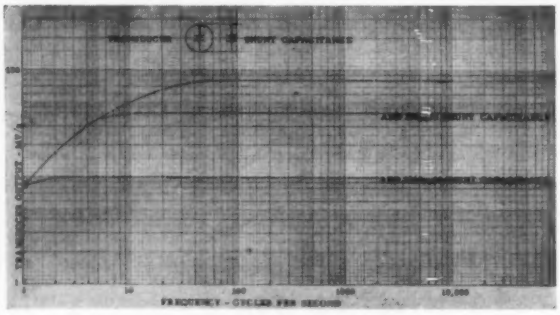

FIGURE 7

Sensitivity vs. frequency response, indicating the effect of shunt capacitance on crystal transducer (transducer capacitance = 180 uufd).

frequency of the 3 db point. Care should be exercised in applying such an approach, however, as there is always a reduction in over-all sensitivity.

Figure 7 illustrates the results of utilizing shunt capacitance across a crystal to obtain improved low frequeny response.

In general, it is quite possible to achieve a frequency response of 2 cps to 12 kc or higher and a dynamic range of .001 to 20,000 g with good crystal accelerometers. Often such ranges are not required, especially at high frequencies, and by utilizing a lower resonant frequency a much higher output sensitivity can be developed.

Filter Parameters

The use of filters in shock measurement has long been subject to debate and certain of the specifications still require filter settings during sand drop machine testing that are not consistent with the manufacturer's calibration detail. Actually, the initial use of a filter in shock test data recording was precipitated by the fact that a sand drop test results in a multitude of high frequency transients, which if not filtered, render data interpretation and machine calibration or comparison virtually impossible. Obviously, however, the peak filtered magnitude of the pulse being observed can be a function of filter characteristics. With some of the newer shock machines filtering is not needed at all because spurious structural response has, for all practical purposes, been eliminated.

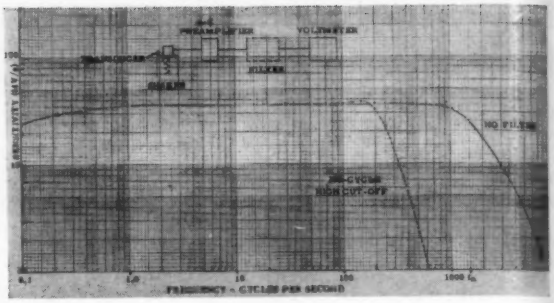

FIGURE 8

Frequency Response Curve for strain gauge type transducer with 1500 cps natural frequency, DC excited, and an AC preamplifier with a frequency response range from .2 cps to 40 kc.

Although the most commonly considered filter parameters are the cut-off frequencies, certain other characteristics are important. Rejection rate, for example, is extremely critical. *Figure 8* indicates the effect of mechanical and electronic filtering on high frequency response. The unbonded strain gauge accelerometer system, shown when unfiltered, tends to fall off naturally at 12 db/octave above the usable range. The use of a filter increases the fall-off or rejection rate to about 24 db/octave. The magnitude of any component occuring in the rejection range would therefore be a function of frequency and rejection rate.

Data Interpretation Problem

When transient pulses of multitudinous frequency content are being measured, as with the sand drop machines, there invariably is a problem of data interpretation. Passive filter networks occasion insertion loss, or signal reduction, and therefore must be carefully calibrated. The ideal filter should have a gain of 1 through the pass band; however, such networks often manifest a gain or overshoot through a certain frequency band, which if exaggerated, can result in "ringing" or pulse distortion.

Figure 9 illustrates the results of such a phenomenon, derived by monitoring a square wave through the instrument. (This phenomenon was actually obtained by utilizing a malfunctioning instrument.) A steady state frequency response obtained by measuring the output through a frequency range and keeping the input voltage from an oscillator constant will also yield the gain on overshoot characteristics.

FIGURE 9

Example of Filter Ringing

(End of Part I. This discussion of shock testing instrumentation will be concluded in the July issue of Environmental Quarterly.)

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Reaction Vibration Machine

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- No special foundation needed to absorb reactive forces.

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FINEST REFRIGERATION SYSTEMS

Compact, so units occupy minimum floor space . . . fully automatic controls for testing under conditions of hi-lo temp, humidity, radiation, and altitude . . . through
Custom Engineered Design

- Hermetically sealed compressors
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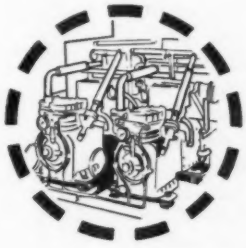

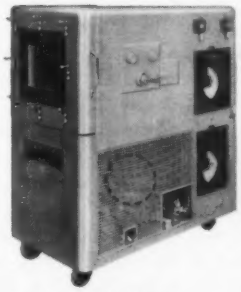

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ANNOUNCING...

A NEW ALPHA LUBRICANT TESTING MACHINE FOR ENVIRONMENTAL RESEARCH

The new Alpha Model LFW-3 Lubricant Testing Machine has been designed to give maximum accuracy and flexibility for environmental research.

It can be adapted to the testing of either dry or liquid lubricants, at ambient to high temperatures, with oscillatory or rotational motion over a wide range of velocities and loads. A high temperature furnace is supplied as standard equipment. Sufficient space in the specimen area, however, will allow future installation of a variety of environmental chambers, including those for low temperature testing. Equipped with a 5 HP motor, the machine will operate at friction coefficients of .5 at full load.

The machine is furnished ready to operate with all electrical equipment necessary to give full protection against overload and low voltage. Instrumentation is mounted in a separate cabinet wired for easy connection to or disconnection from the testing machine.

REVIEW THESE OUTSTANDING FEATURES

- **Easily converted from solid to liquid lubricant testing.**
- **Uniform load distribution over entire test area accurately maintained.**
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- **Highly versatile driving mechanism giving wide range of rotating and oscillating speeds.**
- **Direct and accurate recording of friction forces.**
- **Infinitely adjustable friction limit control for automatic termination of test at preselected friction coefficient.**
- **Infinitely adjustable loading mechanism.**
- **Close control over test temperatures.**

Write today for detailed information and specifications on the Alpha Model LFW-3 as well as other lubricant testing machines in the Alpha line.

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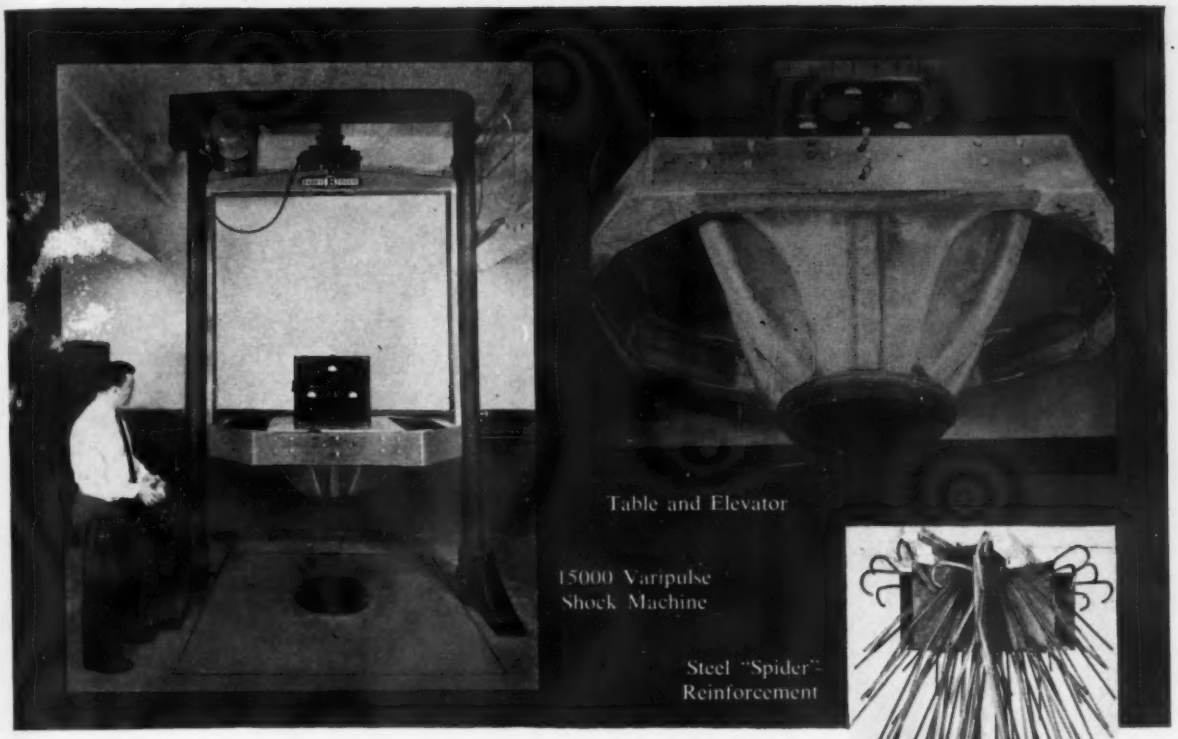

Table and Elevator

15000 Varipulse Shock Machine

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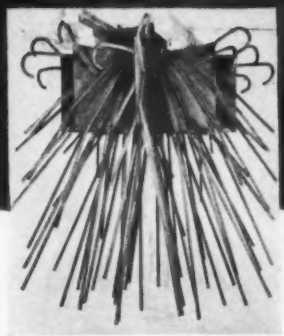

SHOCK TESTING

(THIRD OF A SERIES)

The demand for increased accuracy in instrumentation and the growing importance of shock testing necessitated a precise laboratory tool that would enable the design engineer to anticipate field conditions through laboratory tests.

Ramo-Wooldridge was selected to study the environments in which missile components had to function. From this study were derived the classic R-W shock specification and the definition of the shock spectrum. Basically, the shock spectrum is an envelope defining the maximum acceleration level of a series of resonant members through any specified band-width when subjected to an input shock. This study called for a machine that was capable of producing a 100g peak acceleration with a spectrum that was flat from 100 cps to 700 cps.

From these definitions emerged the Barry 15000 Varipulse shock machine, which started in development in 1956. This machine accommodates test loads thirty inches square and 67 inches high, weighing up to 400 pounds, and it tests with a high degree of accuracy and repeatability. Characteristics of the desired pulse are closely controlled by a combination of drop height and arresting device.

To produce an unprejudiced shock pulse, free from spurious structural resonances, the machine was carefully designed to eliminate distortions. The elevator table is massively rigidized to eliminate all natural frequencies to 1500 cps, and the load table is isolated from superstructure resonances. To eliminate "earth shock" caused by operation, the machine is mounted on a six-foot cube of concrete which houses a steel "spider" that spreads impact force throughout the block and permits tests as high as 300g.

The 15000 Varipulse produces precisely repeatable half-sine pulses by dropping against a rubber pad. Uniform sawtooth pulses are generated by using a shaped lead pellet as the arresting medium.

During the mid-1950's, the increased importance of accurate, repeatable shock tests was evidenced by the development of other methods for generating the required velocity. These included the use of compressed gas and hydraulics.

The basic principle, however, of the gravity drop appeared to be the simplest, safest, and most reliable approach, and Barry Controls next turned to the development of a versatile machine capable of producing a variety of pulses needed to test the growing number of components for missile environments.

(To be continued)

Write for "Correlation of Shock Spectra Pulse Shape with Shock Environment" by R. Lowe and R. D. Cavanaugh.

Leaders in Shock Simulation

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the highest,

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Altitudes to 200,000 ft., temperatures from –100° F to +350° F, in only 4 square feet of floor space. Now, any company can own a combined altitude and temperature test chamber . . . without sacrificing much valuable floor space. And the investment, too, is reasonable.

Only Tenney Engineering, world's largest and most experienced creator of environmental equipment, could produce the Tenney-mite Strat. Write for further information.

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OLDEST AND LARGEST MANUFACTURER OF ENVIRONMENTAL EQUIPMENT

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